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Innovation in Living Labs

Welcome to the February issue of the *Technology Innovation Management Review*. We welcome your comments on the articles in this issue as well as suggestions for future article topics and issue themes.

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Overview

The *Technology Innovation Management Review* (TIM Review) provides insights about the issues and emerging trends relevant to launching and growing technology businesses. The TIM Review focuses on the theories, strategies, and tools that help small and large technology companies succeed.

Our readers are looking for practical ideas they can apply within their own organizations. The TIM Review brings together diverse viewpoints – from academics, entrepreneurs, companies of all sizes, the public sector, the community sector, and others – to bridge the gap between theory and practice. In particular, we focus on the topics of technology and global entrepreneurship in small and large companies.

We welcome input from readers into upcoming themes. Please visit timreview.ca to suggest themes and nominate authors and guest editors.

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Editorial: Innovation in Living Labs

Chris McPhee, Editor-in-Chief

Seppo Leminen, Mika Westerlund, Dimitri Schuurman, and Pieter Ballon, Guest Editors

From the Editor-in-Chief

Welcome to the February issue of the *Technology Innovation Management Review* – the second of two issues on the theme of **Innovation in Living Labs**. It is my pleasure to introduce our guest editors: **Seppo Leminen** (Laurea University of Applied Sciences and Aalto University, Finland, as well as Carleton University, Canada), **Mika Westerlund** (Carleton University), **Dimitri Schuurman** (imec and Ghent University, Belgium), and **Pieter Ballon** (VUB, Belgium).

For future issues, we welcome your submissions of articles on technology entrepreneurship, innovation management, and other topics relevant to launching and growing technology companies and solving practical problems in emerging domains. Please contact us (timreview.ca/contact) with potential article topics and submissions.

Chris McPhee
Editor-in-Chief

From the Guest Editors

We are delighted to introduce the second of two special issues on the theme of **Innovation in Living Labs**. The February issue is the seventh in the series of special issues of the *Technology Innovation Management Review* focusing on living labs (McPhee et al., 2012; McPhee et al., 2013a,b; McPhee et al., 2015; McPhee et al., 2016; McPhee et al., 2017).

As with the January issue, most of the articles in this issue were carefully selected and revised from papers at the OpenLivingLab Days 2016, held from August 23 to 26 in Montreal, Canada. Accordingly, we would like to invite you to the OpenLivingLab Days 2017 to be held in Krakow, Poland on August 29 through September 1, 2017. The conference will feature designated living lab tracks and workshops by the European Network of Living Labs (ENoLL; openlivinglabs.eu), and it gathers numerous living lab practitioners and scholars worldwide.

As the field advances, there is greater and greater diversity in topics covered and approaches taken in living labs practice as well as research (cf. Bergvall-Kåreborn et al., 2015; Brankaert et al., 2015; Dell'Era & Landoni, 2014; Dutilleul et al., 2010; Edvardsson et al., 2012; Femeniás &, Hagbert, 2013; Guimont & Lapointe, 2016; Hakkarainen & Hyysalo, 2016; Leminen, 2015; Leminen et al., 2012, 2015, 2016; Nyström et al., 2014; Rits et al., 2015; Schuurman et al., 2016; Ståhlbröst & Lassinantti, 2015; Veeckman et al., 2013; Westerlund & Leminen, 2011). The early living lab literature not only focuses on explaining innovation and development activities with users in different contexts but also offers a broad variety of definitions. The recent literature reveals methods and conceptualizations for the benefit of managers and researchers. Moreover, Leminen (2015) and Leminen and Westerlund (2016) categorize prior studies to diverse research avenues based on an extensive literature review. Following this categorization, the present special issue focuses on revealing methods, methodologies, and approaches in living labs.

Editorial: Innovation in Living Labs

Chris McPhee, Seppo Leminen, Mika Westerlund, Dimitri Schuurman, and Pieter Ballon

The first article, by **Sonja Pedell**, **Alen Keirnan**, **Gareth Priday**, **Tim Miller**, **Antonette Mendoza**, **Antonio Lopez-Lorca**, and **Leon Sterling** from Melbourne, Australia, focuses on methods to support the elicitation of emotions. The study is based on qualitative research and design methods including interviews, animations, and storyboards. So doing, it contributes to the living lab literature by demonstrating how emotion-led methods and goal models can be used at various stages of the living lab process.

The second article, by **Ruben D'Hauwers**, **Aron-Levi Herregodts**, **Annabel Georges**, **Lynn Coorevits**, **Dimitri Schuurman**, **Olivier Rits**, and **Pieter Ballon** from imec, VUB, and Ghent University, Belgium, examines business-to-business living lab projects. The authors use an action research approach to study eight living lab cases in Belgium. Their study identifies three main barriers that prevent real-life experimentation in business-to-business living lab projects. The authors emphasize the need for providing guidelines for real-life testing and panel management in a business-to-business context.

The third article, by **Anna Ståhlbröst** and **Marita Holst** from Luleå University of Technology, Sweden, reflects on a development method to stimulate learning and adoption of digital innovations. The article is based on a research project financed by the European Commission and proposes that end users are able to change their energy consumption behaviour based on the results of living lab activities. The article concludes by proposing that complexity may lead to processes that are difficult to predict in advance.

In the fourth article, **Sara Logghe** and **Dimitri Schuurman** from imec and Ghent University, Belgium, illuminate an action research approach to capture delights and frustrations of panel members in living labs. The article is designed on a qualitative research approach including three living lab projects in Belgium. It contributes to the literature by recommending that living lab operations benefit from a combined action research and living lab approach, including active involvement of panel members themselves.

Finally, in the fifth article, **Louise Savelkoul** and **Murk Peutz** from Equator Research in the Netherlands examine the structured needsfinding phase of a living lab infrastructure project. The data were collected through a questionnaire to measure bicycle commuting intention. The results of the research lead to practical guidelines when developing fast cycling routes.

It is evident that the articles in this special issue illustrate that living labs are a blossoming research domain. We hope that you enjoy the issue and consider utilizing the potential and opportunities of living labs in your organization. Finally, we encourage living lab researchers as well as other innovation scholars to take further research actions into the different aspects of living labs.

Seppo Leminen, Mika Westerlund, Dimitri Schuurman, and Pieter Ballon
Guest Editors

Editorial: Innovation in Living Labs

Chris McPhee, Seppo Leminen, Mika Westerlund, Dimitri Schuurman, and Pieter Ballon

About the Editors

Chris McPhee is Editor-in-Chief of the *Technology Innovation Management Review*. He holds an MASc degree in Technology Innovation Management from Carleton University in Ottawa, Canada, and BScH and MSc degrees in Biology from Queen's University in Kingston, Canada. Chris has nearly 20 years of management, design, and content-development experience in Canada and Scotland, primarily in the science, health, and education sectors. As an advisor and editor, he helps entrepreneurs, executives, and researchers develop and express their ideas.

Seppo Leminen is a Principal Lecturer at the Laurea University of Applied Sciences and serves as an Adjunct Professor of Business Development at Aalto University in Finland and an Adjunct Research Professor at Carleton University in Canada. He holds a doctoral degree in Marketing from the Hanken School of Economics and a doctoral degree in Industrial Engineering and Management in the School of Science at Aalto University. His research and consulting interests include living labs, open innovation, innovation ecosystems, robotics, the Internet of Things (IoT), as well as management models in high-tech and service-intensive industries. Results from his research have been reported in *Industrial Marketing Management,* the *Journal of Engineering and Technology Management,* the *Journal of Business & Industrial Marketing, Management Decision,* the *International Journal of Technology Management*, the *International Journal of Technology Marketing,* the *International Journal of Product Development,* and the *Technology Innovation Management Review,* among many others.

Mika Westerlund, DSc (Econ), is an Associate Professor at Carleton University in Ottawa, Canada. He previously held positions as a Postdoctoral Scholar in the Haas School of Business at the University of California Berkeley and in the School of Economics at Aalto University in Helsinki, Finland. Mika earned his doctoral degree in Marketing from the Helsinki School of Economics in Finland. His current research interests include open and user innovation, the Internet of Things, business strategy, and management models in high-tech and service-intensive industries.

Dimitri Schuurman is the Team Lead in User Research at imec.livinglabs and a Senior Researcher at imec – MICT – Ghent University in Belgium. He holds a PhD and a Master's degree in Communication Sciences from Ghent University. Together with his imec colleagues, Dimitri developed a specific living lab offering targeted at entrepreneurs in which he has managed over 100 innovation projects. Dimitri is responsible for the methodology and academic valorization of these living lab projects and coordinates a dynamic team of living lab researchers. His main interests and research topics are situated in the domains of open innovation, user innovation, and innovation management. His PhD thesis was entitled *Bridging the Gap between Open and User Innovation? Exploring the Value of Living Labs as a Means to Structure User Contribution and Manage Distributed Innovation.*

Pieter Ballon is the Academic Lead of imec.livinglabs, the International Secretary of the European Network of Living Labs, and Director of the research group imec-SMIT at Vrije Universiteit Brussel in Belgium. He specializes in business modelling, open innovation, and the mobile telecommunications industry. Formerly, he was Senior Consultant and Team Leader at TNO. In 2006–2007, he was the coordinator of the cross issue on business models of the Wireless World Initiative (WWI), which united five integrated projects in the European Union's 6th Framework Programme. Pieter holds a PhD in Communication Sciences from Vrije Universiteit Brussel and a MA in Modern History from Katholieke Universiteit Leuven.

Editorial: Innovation in Living Labs

Chris McPhee, Seppo Leminen, Mika Westerlund, Dimitri Schuurman, and Pieter Ballon

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Keywords: living labs, innovation, emotions, action research, business-to-business, reflection, operations, needsfinding

Methods for Supporting Older Users in Communicating Their Emotions at Different Phases of a Living Lab Project

Sonja Pedell, Alen Keirnan, Gareth Priday, Tim Miller,
Antonette Mendoza, Antonio Lopez-Lorca, and Leon Sterling

> *"The great secret that all old people share is that you really haven't changed in seventy or eighty years. Your body changes, but you don't change at all. And that, of course, causes great confusion."*
>
> Doris Lessing (1919–2013)
> Writer and Nobel Laureate in Literature (2007)

In this article, we focus on living lab methods that support the elicitation of emotions – a key success factor in whether a design solution will be accepted and taken up over the long term. We demonstrate the use of emotional goal models to help understand what is relevant for a target user group in the early phases of design. We promote animations and storyboards to envision the context of use and to gain an understanding of how design ideas can integrate into people's lives. For the evaluation of ideas and to further understand user needs, we show how technology probes facilitate natural interactions with a suggested solution concept. All methods have in common that they enable older adults without design or development experience to participate in the design process and work towards a meaningful solution by helping to communicate feelings and goals that are often hard to define. Lastly, we present a process model that demonstrates our emotion-led design toolkit at various phases of a living lab process.

Introduction

Each design and research process consists of varied methods that are fundamental to realizing user goals. In this article, we demonstrate how our methods can be used within three generic living lab design phases: exploration, experimentation, and evaluation (Schuurman et al., 2016). We apply our methods in a living lab project to give older adults a strong voice to share and describe their experiences and emotions and to explore how these insights can be captured for design purposes. The project objective was to develop an innovative personal emergency alarm that evokes positive emotions in older adults and reduces the feeling of "being monitored". We ask the question:

> *"What methods cater for the goals and emotions of older adults in a co-design process to develop innovative solutions?"*

We propose an emotion-led design toolkit with several artefacts: motivational goal models, animations, and technology probes. We argue that using these artefacts at different phases of a living lab project cycle facilitates effective communication between participant stakeholders and contributes to both innovation and service design methodologies. Service design and user-driven design methods are increasingly important aspects of living labs, recognized as two means of increasing user acceptance of innovations (e.g., the FormIT methodology [Ståhlbröst &Holst, 2013] and citizen-driven innovation [Eskelinen et al., 2015; Gray et al., 2014]. This view is in alignment with Muller (2007) who argued a decade ago that user engagement is too often one-directional, creating applications of technology rather than solutions to user problems.

The following sections report on emotions in designing for health, followed by a review of existing living lab processes. We show how our emotion-led design toolkit can support the phases of a typical living lab process, demonstrated through a case study of personal alarm systems.

Emotions in Designing for Health

In the discipline of design, emotions influence decisions about the look and feel of products and services. For a personal topic such as health, people's emotions play a major role in the success of a technology, and they afford an opportunity to increase compliance (Lo Bianco et al., 2015).

Yet, design of systems in the domain of health services is still functionality-driven rather than emotion-driven, particularly when institutions, as main stakeholders, fulfill government policies and focus on compliance and liability towards patients rather than patients' feelings. Here, we complement functional-driven design with users' desired emotions in order to develop innovative products with a high uptake (see Figure 1).

Personal alarm systems are an example of technology that has high impact potential but neglects the emotional needs of older people (Miller et al., 2015). Personal alarm systems typically have two features: i) a wearable personal device – the user can raise an alarm if they require emergency attention, for example by pushing a button on a wristband or a pendant worn around the user's neck; and ii) a wellbeing check – the user informs the service provider that they are fine, usually on a daily basis, for example, by pushing a button on a base station connected to a telephone line. In the second case, if no indication of wellbeing is received during the specified period, the service provider initiates checks on the user (Pedell et al., 2014). In this article, the term "personal alarm system" will be used to describe both features: the wellbeing check and the personal device.

The Living Lab Phases: Exploration, Experimentation, and Evaluation

Many studies have noted the importance of real-life contexts and the involvement of end users in living lab innovation processes (Almirall et al., 2012; Leminen, 2015; Veeckman et al., 2013). The end users of potential innovations are seen as "co-creators" (Veeckman et al., 2013) in the innovation process rather than subjects of study. Dell'Era and Landoni (2014) highlight the importance of the research-led aspect of living labs while also emphasizing the importance of users as active co-creators and the real-life context as a factor that modifies the users' needs.

Although individual living labs have different overall approaches (Almirall et al., 2012), there are many similarities. The FormIT methodology (Ståhlbröst & Holst, 2013) illustrates a typical approach, which emphasizes user involvement in the innovation lifecycle from ideation through to eventual commercialization. Schuurman and colleagues (2016) have identified three generic phases that are common to many living labs: exploration (idea/concept), experimentation (prototyping), and evaluation (pre-launch, launch, and post-launch). Their study also shows that the more closely a living lab approach follows this "ideal" approach, including multi-method user involvement, the greater the positive impact on the final outcome. Leminen and colleagues (2015) note four different user roles within a living lab – informant, tester, contributor, and co-creator – although they indicate that each user can perform multiple roles. The informant contributes an understanding about the users' life, problems, and needs. The tester

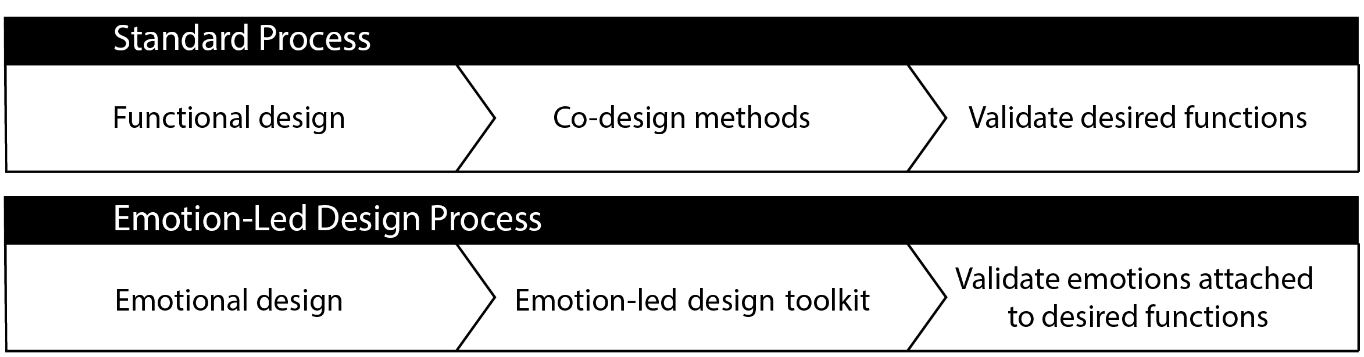

Figure 1. Comparison model showing the difference between a standard process and an emotion-led design process with emphasis on understanding users' emotions

evaluates innovations in the environment. The contributor collaborates with the other stakeholders in the development of a service. Finally, the co-creator creates and develops actual solutions with the other stakeholders. Leminen and colleagues (2015) show that the first three roles are most common in living lab projects. Co-creative methods have been established in research as "people who are not professional technology designers may not be able to define what they want from a design process, without knowing what is possible. A process of mutual learning for both designers and users can inform all participants' capacities to envisage future technologies and the practices in which they can be embedded" (Robertson & Simonsen, 2012). However, recent literature has recognized the challenge of actively engaging older adults in design processes and have come up with methods to do this (Edlin-White et al., 2012; Lindsay et al., 2012; Vines et al., 2012; Waycott et al., 2012; Waycott et al., 2013). What we contribute here is a means to specifically integrate emotions in a co-creative living lab process. Table 1 summarizes our emotion-led methods, aligned with the three typical phases of living lab methodologies identified by Schuurman and colleagues (2016).

Phase 1: Exploration

Our case study focuses on the use of methods to enable the exploration and evaluation of emotions with older adults around personal alarm systems and their wider context of use as a means of innovating both the function and the service offering. In the conceptual phase, we report on the development of an early goal model, with emotions captured from initial exploration and in-depth interviews where the users are operating in the role of an informant.

Participants, data collection, and analysis
Twelve in-depth interviews were conducted, categorized into three groups: i) older people who lived alone (with one exception) and who either currently have or previously have had a personal alarm system installed in their home; ii) family members of older adults who either currently have or previously have had a personal alarm system installed into their home; and iii) older people who never have had a personal alarm system installed in their home. The interviewees in the first group were older than the interviewees in the last group: those who had experience with personal alarm systems ranged from 85 to 91 years of age, whereas those who did not have experience with personal alarm systems ranged from 66 to 79 years of age.

The interviews explored three key questions: What should an alarm technology do (functions)? How should it be (qualities)? and How should it feel (emotional response)? We transcribed the data using content analysis according to Patton (2002) and derived common themes from the data.

Results: Emotions around personal alarm system use
Our interviews revealed that some older people perceived that their feelings were not being taken into consideration. They viewed the wearable pendants as "cowbells" forced onto them:

> *"She always would joke about her cowbell, and complain about it. 'Look at what my kids are making me do,' kind of comment, a slight resentfulness about it. And it was kind of against her independence."* [Participating relative]

The pendants were perceived by the wearers as having a "stigma" attached to them – a perception that others be-

Table 1. A process table outlining the phases in which emotion-led methods are employed during a standard living lab process, in context of a personal alarm living lab project

Phase 1: Exploration	Phase 2: Experimentation	Phase 3: Evaluation
Initial investigation	Scenario design	Tech probe design
In depth interviews	Co-evaluation of scenario	Define user needs
Early goal model	Goal model refinement	Concept refinement

lieve the wearers are no longer are able to care for themselves, resulting in the pendants not being worn. The considerations and social environment around the decision of whether or not to wear the pendant were complex and loaded with emotions. The complexity is expressed well by the nephew of one of the users:

"So we did have the discussion and she sort of admitted that she didn't want to wear it and she didn't think that she should and she understood the risks and she was prepared to take the risks and that she didn't want to upset me and she didn't want me to feel like she wasn't cooperating with me. And so she said [mimicked aunts voice] 'so at least I wore it some of the time'. You know these times when she was wearing it was when someone was there and she didn't really need it. But for her, that was her compromise." [Participating relative]

It became clear that personal alarm systems need to consider more than just safety aspects. The pendant limits mobility in that the alarm only works in the owner's house, so that the wearer might be hesitant to leave their home. Interestingly, most pendants have an effective range of 300 metres, but despite the strong feeling of being confined to a small space, older users are told that the maximum range is about only 70 metres in order to better pinpoint a wearer's location in an emergency. The limitations this information poses to the older person in their everyday life apparently are not considered by service providers.

The wellbeing check (the second component of the system) requires the user to remember to push a button each day. Otherwise, the service provider calls to check upon the client, which leads many older people to feel they are a burden, despite paying for the service. Others feel that they are perceived by their families as suffering from memory loss:

"And no matter what system I try [claps with hand on his knee in frustration and enforcement several times] I still manage out of 10 days that I miss out 2 or 3 times by completely forgetting and that is what ANNOYS [emphasis] me." [Older user]

Pressing the button on the wellbeing check base station does not convey any meaning to the older person and is therefore forgotten. Additionally, the wellbeing check provides no feedback indicating whether the button has been pressed on a particular day. Pressing the button on the wellbeing check a second time on the same day initiates an inquiry to the service providers and is perceived as a signal of an emergency. Hence some older people do not feel confident using the system. Further, the wellbeing check is not easily configurable, for example, users cannot adjust the time of day when the wellbeing button should be pushed, which leaves users feeling that they are not in control of the system.

The older people we interviewed indicated a desire for the personal alarm system, in particular the wellbeing check, to evoke feelings of independence, safety, being in touch with other people, control, and integration. Most importantly, they wanted to feel cared about. Table 2 provides an overview of the captured emotions.

Based on the emotions we captured, we integrated the emotional goals into a motivational goal model according to the notation of Sterling and Taveter (2009), extended by Marshall (2014), as shown in Figure 2. In this model, emotions (hearts) are attached together with desired qualities (cloud shapes) to functional goals (parallelograms). The emotions were used as high-level specifications in the following phases of the design process to develop a prototype and the final design of the personal alarm system.

Table 2. Overview of current and preferred emotions surrounding personal alarm systems

Current Emotions about the Personal Alarm System		Preferred Emotions about the Personal Alarm System	
Resentfulness	A burden on other people	In touch	Integrated
Not independent	Not confident	Independent	Cared about
Stigmatizing	Not in control	Safe	In control

Methods for Communicating Emotions at Different Phases of a Living Lab Project
S. Pedell, A. Keirnan, G. Priday, T. Miller, A. Mendoza, A. Lopez-Lorca, and L. Sterling

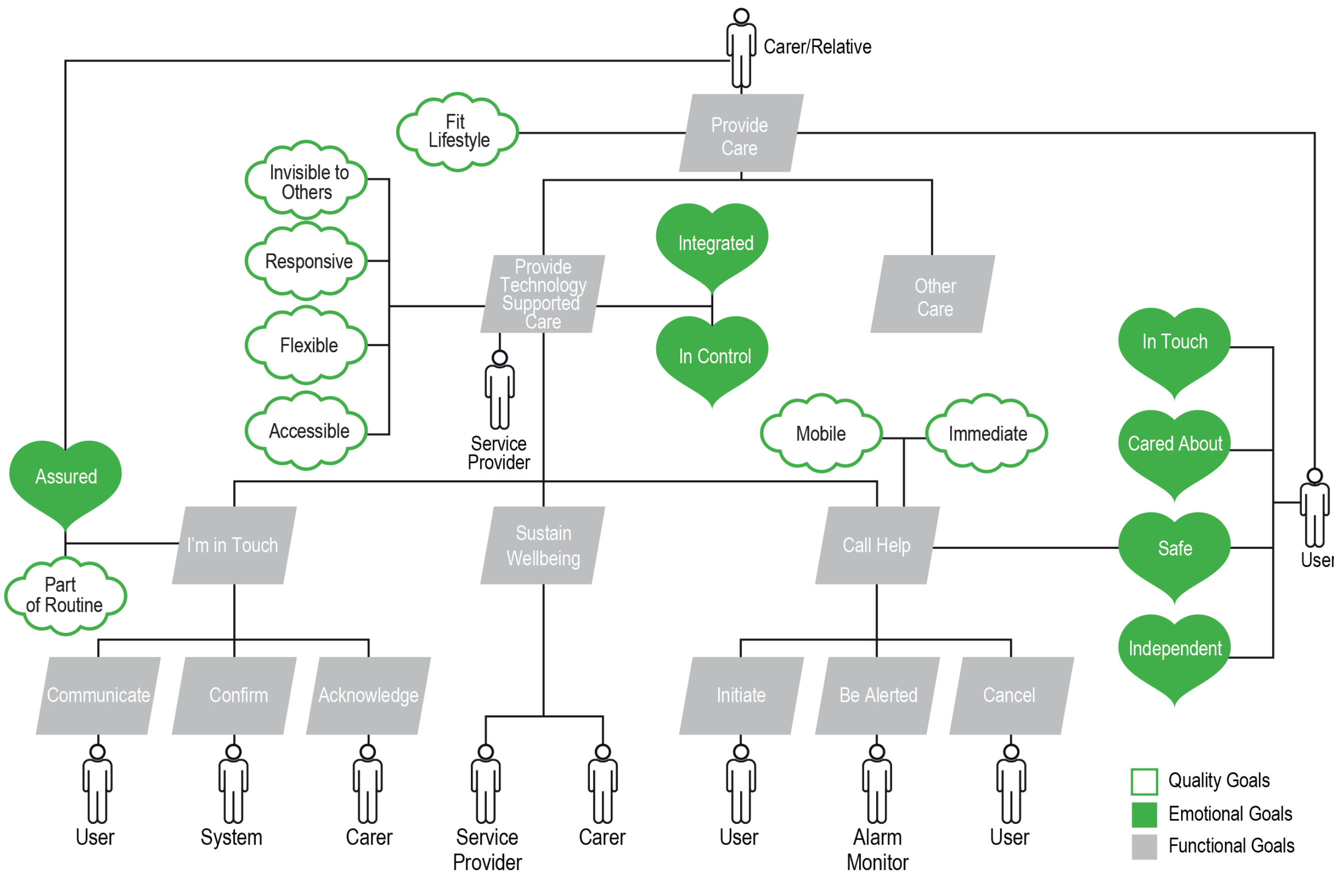

Figure 2. Mapping functional, quality, and emotional goals with stakeholder roles and system interactions

In order to ensure a smooth transition from the exploration to the experimentation stage, we suggest that the outcomes of the exploration phase, namely the emotional goal model, should be validated in its context of use with the prospective end users. The goal models are intended as high-level specifications for designers and developers to create a prototype.

Phase 2: Experimentation

In technology development, we face the challenge of anticipating how technology will be adopted and integrated into people's lives. Technology itself changes our lives — how we perceive and handle situations (described by Carroll and Rosson (1992) as the task-artefact-cycle). Although user-centered design and experience design (Buxton, 2007) help us envision future use by better understanding users' lives, designers still face a problem of validating future use scenarios before creating a solution. Future users themselves often have no clear understanding of the implications new technologies will have on their lives and are thus limited in giving input into design decisions. When changing existing situations into preferred ones (Simon, 1982), a designer with input from end users should strive to understand contexts, issues, relationships, environments, and emotions where a design problem is situated. Scenarios one of many useful tools in a designer's toolkit (Loke et al., 2005) and are used to understand the complexities of the design context (Iacucci et al., 2002). Here, we use scenarios, or imagined stories of events, during the experimentation phase as means to explore design options, anticipate future problems, and describe contexts of user experiences with products (Lim & Sato, 2005; Mathews & Heinemann, 2012). We therefore develop a new approach to animate current and future use scenarios with emphasis placed on the early emotional goal model described in the exploration phase. In doing so, we aim to envision and visualize future technology use. We suggest that animated scenarios can be used as a tool to co-evaluate earlier insights of user research with participants, particularly surrounding sensitive issues such as feelings and personal life goals. We also expect that, by co-evaluating insights from the conceptual phase using animated scenarios, participants can express their own emotions using personas and those emotions can be better expressed in animations rather than written or sketched scenarios.

Scenario design: Creating the animations
We created three animations (Figure 3) based on the existing interview data, including emotions around personal alarm system use, from the exploration phase. These animations were used to co-evaluate the goal model and validate the barriers and reasons older adults do not use current personal alarm systems.

Our three aims for the use of the animations for co-evaluation as a means to explore future scenarios were:

1. To determine whether the problems presented in the scenarios were identified and interpreted in similar ways by the participants reflecting on their own situation.

2. To determine if the animated scenarios reflected a realistic story (context) of a user involved with personal alarm systems, with particular focus on both operating the pendant and conducting daily well-being checks.

3. To encourage participant feedback to help redesign a new personal alarm system once a shared understanding about the relevance of the scenarios was established.

In a co-design workshop with four older people, we discussed these animations. According to Massimi and colleagues (2007), a participant number of four was considered to be suitable due to the personal nature of the topic, creating a familiar environment of "having tea together". People with and without alarm pendants discussed the scenario in pairs, including feelings about the personas, intervention points in the scenario, and design ideas to improve feelings and living situation of the people depicted in the scenarios. In this case, users act as both informants, who correct understanding of the situation, and contributors, who collaborate to develop the service design.

Results using animated scenarios and storyboards
When shown the animations, participants were engaged with the plot of the story. This engagement became particularly clear after participants commented on the animations after viewing them, because they related feelings of the animated personas to their own life situations. We confirmed that the three scenarios and the depicted emotions were perceived as realistic and something the participants could relate to in their own lives, but we were also able to create an atmosphere of openness that provided a foundation for engaging the participants in co-creative design activities. Using printed storyboards (Figure 4), the participants identified and commented on aspects of the animations in which personas needed to be better understood by their relatives and service providers with implications for design.

Design ideas were directly put into the context of the scenario. The ideas were adjusted until the scenario reflected a true reality for a personal alarm user, as shown by the annotations in Figure 4. For example, the size of the pendant was not problematic for participants, but merely its appearance. Figure 5 shows an example of one of the ideas generated in the workshop: the pendants could be redesigned to be worn as a piece of jewellery.

Figure 3. Screen captures of animated scenarios. Left: "I forgot", middle: "Cow Bell", right: "Dress Code"

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Figure 4. An example of an animation storyboard with annotations from workshop participants

Figure 5. A user wearing an alarm pendant (left) and a workshop participant showing an item of her own jewellery as a pendant redesign idea (right)

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We found that the animated scenarios helped us to better include older people in the decision and design processes and to validate some of the imagined everyday scenarios of use. The older adults' emotions and their motivations were key in this process. Animations are well suited to expressing such emotions. The storyboards were a good way to capture comments and ideas generated by these animations.

Phase 3: Evaluation

Probes are particularly suited to investigating people's everyday life in situations difficult to reach with traditional social science methods such as questionnaires, interviews, focus groups, or participant observations. Rather than relying on the presence and intervention of the researcher, probes are designed to encourage and empower subjects to collect data themselves (Arnold, 2004). The participants use probes to provide some insight, at their discretion, about their daily lives. Often, challenges and opportunities are only discovered when the technologies are used and evaluated with users in real-world settings (Doyle et al., 2010; Waycott et al., 2012). Personal information and story generation are two important benefits that we see here in the use of probes as artefacts contributing to users' point of view. Due to the logging functionality, technology probes ensure that participation of a user is visible and re-countable (Graham & Rouncefield, 2007).

The technology probe was seen as instance of the goal model and had logging capabilities (as is typical of technology probes) to monitor and record the use of the application. At the beginning of the field study, none of the researchers, designers, or older adults had a clear idea about how the final personal alarm system technology would look. It was particularly important to first engage the participants in simple technology use so they could confidently handle the interaction with their family members. Future design is thus grounded in a thorough understanding of users' experiences, requirements, and preferences (Lindsay et al.,2012).

Generally, technology probes can collect data about use to inform a better understanding, not so much about how to improve the technology but rather about actual needs in supporting specific activities (in our case activities evolving around building and maintaining interactions of older adults and their relatives to communicate wellbeing) (also see Hutchinson et al., 2003). Hence, technology probes are conducted prior to actual prototyping of the future system. In these latter phases, the users are acting as testers of the technology probe as well as collaborators influencing the evolving design as the functional and emotional goal models are refined through the supporting interview processes.

Prototype development: Technology probe for the wellbeing check

The technology probe for the wellbeing check was motivated by the goal model (see Figure 1) and facilitated the involvement with the user. The technology probe focused on the daily wellbeing check, rather than the pendant. We collaborated with a software company that followed an agile development approach. The emotional goals were communicated to the company and they defined their development goals in alignment with the emotional goals and mirrored their daily progress on each of them. The technology probe development and communication about alternatives was driven by the emotional goals. The technology shown in Figure 6 was developed and implemented in nine households.

The prototype in Figure 6 enabled relatives to send photos with captions. The user had could then scroll through photos and send messages back to their relatives. Only when no interaction takes place over a defined period of time does the app ask the user to indicate their wellbeing (e.g., "You haven't been in touch. Are you ok?"), and the user responds by pressing a button in the app. Thus, the wellbeing check in this prototype is the existence or absence of this "ping" as monitored by the backend systems of a service provider.

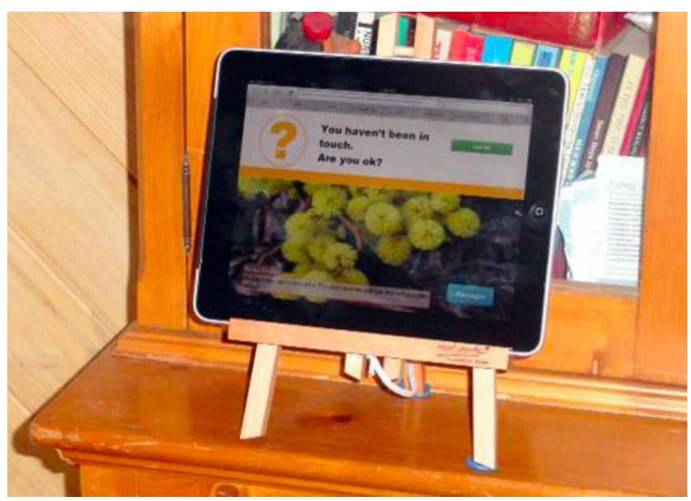

Figure 6. IPad with picture app used as base station for wellbeing check

Evaluation: Results from implementing the technology probe for the wellbeing check

Older people and relatives (nine older participants and five relatives) were interviewed after a four-week trial with the implemented technology probe for the wellbeing check. Overall, the participants liked the social and personalized aspect of the application and the feedback was positive. One relative commented:

"It's really fantastic. Because it's not masquerading or trying to pretend it's something that it's not. It's harnessing that activity, or harnessing that interaction to mine it for really useful data, so it's not […] the teddy bear with the hidden camera in it monitoring what's going on in the room, it's not presenting in that way. It's very upfront." [Relative]

However, although one participant was happy with the social aspect, they were not comfortable with the monitoring aspect of the alarm and still felt that control was taken away from her.

"I wouldn't want to have any automatic checking on me. I want to be in control of whether someone is coming. I want to make a conscious decision. Last year, I had really high blood pressure and I went to bed and thought 'either I will wake up or not and that is fine'." [Older person]

The technology probe for the wellbeing check, coupled with interviews, enabled us to view the goal qualities in the light of the user activities.

However, it was very difficult for us to meet the expectations of some older people to truly feel "cared about". The following quote summarizes the different expectations:

"I think that that's the conflict because, for me as a relative and a carer, the assuredness was related to the functional aspects of the device, whereas for the user, their assurance isn't related to that at all. Their assurance is much more around the emotional ideas and that idea around the connectivity. And I think that was the clash, in that what I emotionally needed was very different to what my aunt emotionally needed.[…] and the reason that we implemented the system was... I mean to put it really bluntly was farming out a task." [Relative]

In our solution, we expect a certain commitment of relatives and carers to spend some time in communicating with the older person. It was difficult to find people in this trial that would send a photo to the older person every day. Although we try to meet the emotional goals of older people, we are aware that we rely on other people whose emotions or time allowance might not be in alignment with those of the older person.

The Emotion-Led Design ToolKit

Here, we summarize the use of the different emotion-led methods used in the three phases of the living lab process. The first phase of the process (exploration) begins with the designer conducting user research around a design problem or theme. Our design problem focused on personal alarm systems for older adults. Collections of insights are formed during this phase and then are translated into a goal model with a focus on emotions (Figure 7).

Emotions gathered during the exploration phase are represented in the goal model and are crucial in moving towards a designed outcome. It is important for researchers to evaluate these emotional goals to ensure that they reflect the true nature of the design problem. During the exploration phase, the researcher begins to create individual scenarios that show the emotional goals of the user and the functional goals of the system in context. It is presented to end users in the format of

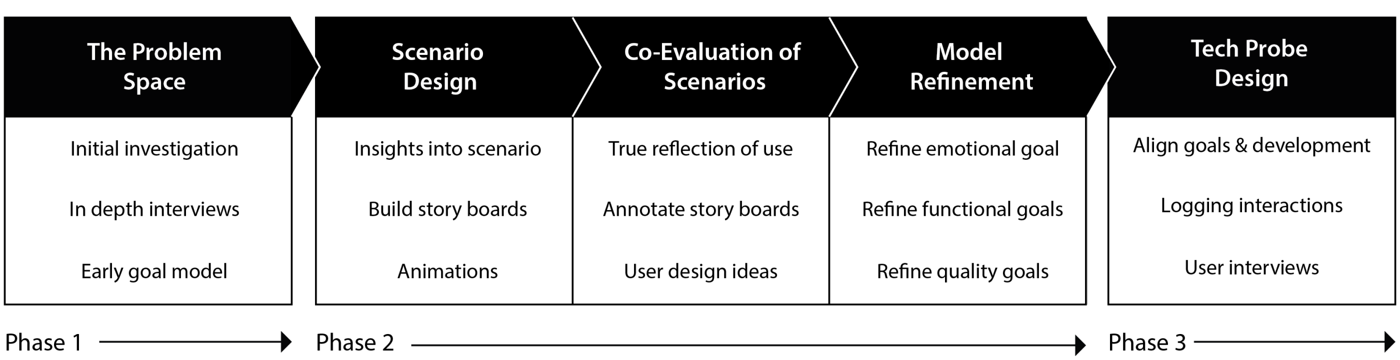

Figure 7. A process flow model illustrating the emotion-led design toolkit to supports the living lab process from exploration (Phase 1), to experimentation (Phase 2), and then to evaluation (Phase 3)

animations to co-evaluate initial user research from the conceptual phase to ensure the goals reflect the key concerns and emotions of the users that need to be addressed in the design solution. In our case, we focused on the older adults as the main users of the system. We suggest that it would be useful to repeat the co-evaluation with other main stakeholders, such as relatives and carers. Evaluation is the last phase of the working model. It is here, after the scenarios have been refined and themes and insights have been developed and evaluated with the user, that a designer can work towards a designed outcome.

Conclusion

In this case study, our approach conforms to an overall model that is typical of living labs. We take a similar iterative developmental approach from exploration, to experimentation, and then to the early stages of evaluation. Our users took on the typical living lab roles of informants, testers, contributors, and co-creators and were involved in multi-method approaches throughout the lifecycle. Our study proposes an emotion-led design toolkit that can be added to similar approaches in other living labs. This approach captures the emotional and quality goals of older adults (in this case) and translates them into actionable requirements that sit alongside functional goals. We show that motivational goal models are a suitable way to express field data derived from interviews – in particular emotions of users. These models are part of a development methodology and can be combined with scenarios to express user's emotions, motivations, and roles (Marshall, 2014; Sterling & Taveter, 2009), each of them describing and providing context of the domain. The goal models provide a place where abstract design concepts can be collected and represented (Pedell et al., 2009), but it will also be possible to evaluate final solutions against these goals. They are a lens through which use activities can be analyzed and recorded and then discussed among researchers and older adults. In reflection of our initial aim to give older adults a strong voice in the design process, the technology probes facilitated natural interactions between family members and yielded useful insights into how they used the newly designed system. Data gathered using technology probes are fragmentary and unstructured, which makes the process of translation from field data to abstract generalization for development difficult. A process of combining technology probe data collection and motivational goal models allowed us to talk about intangible outcomes with users that can be surprising, complex, and subtle.

To conclude, we emphasize the contribution of this research, which is a demonstration of how goal models, animations, and technology probes can be used to refine, link, and strengthen the transitions from different phases of a living lab process.

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Overcoming Barriers to Experimentation in Business-to-Business Living Labs

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" There are three principal means of acquiring knowledge: observation of nature, reflection, and experimentation. Observation collects facts; reflection combines them; experimentation verifies the result of that combination. "

Denis Diderot (1713–1784)
Philosopher, art critic, and writer

Business-to-business (B2B) living lab projects have been mentioned in different areas of academic research, but the innovation management literature requires deeper analysis of their potential opportunities and challenges. Real-life experimentation is a key requirement for living labs as it enables deeper insights in the potential success of innovations. However, the literature has not provided insights on how living lab projects can implement real-life experimentation in B2B innovation projects and does not describe appropriate conditions for experimentation in these settings. In this study, we identified three main barriers preventing real-life experimentation in B2B living lab projects: the technological complexity, the need for integration, and the difficulty in identifying testers. The barriers are discussed in detailed and potential solutions are provided to help overcome these barriers and stimulate the adoption of real-life experimentation in B2B innovation projects.

Introduction

Providers of "living labs as a service" – who offer services such as designing the idea-generation processes, planning or carrying out real-world tests of innovations, and assessing pre-market launches (Ståhlbröst, 2013) – are confronted with an ever-increasing demand for B2B-oriented projects. B2B companies focus on transactions between companies, whereas business-to-consumer (B2C) companies sell their products directly to the end user (Chauhan & Anbalagan, 2014). Both B2B and B2C innovation projects are confronted with a range of uncertainties throughout their development process, but much of the focus of the living lab literature has been on B2C projects.

In this article, we draw upon experiences dating back to 2005 with the establishment of iLab.o, the predecessor of iMinds Living Labs, which is now imec.livinglabs (imec-int.com/en/livinglabs). The organization's first projects were situated in a B2C context (see Schuurman [2015] for a detailed historical overview). However, as iLab.o evolved into a living-lab-as-a-service offering and started to attract more and more utilizers, we witnessed an inflow of B2B projects (see Schuurman et al. [2016] for an overview of the projects). While putting the proof-tested methods used by open innovation research in B2C projects into practice in a B2B environment, we discovered that the application of real-life experimentation in B2B-oriented living lab projects poses particular methodological as well as practical challenges. Given that real-life testing with potential users of the innovation is one of the main characteristics of living labs, and the literature on B2B living lab projects is scant, we aim to contribute to the academic literature by analyzing opportunities for real-life testing in eight case studies of B2B living labs. Through a cross-case analysis, we identify the main barriers to B2B experimentation and their respective potential solutions.

Overcoming Barriers to Experimentation in Business-to-Business Living Labs

R. D'Hauwers, A.-L. Herregodts, A. Georges, L. Coorevits, D. Schuurman, O. Rits, and P. Ballon

Living Labs and Real-Life Experimentation

In the context of living labs, the innovation process has evolved from a single-inventor perspective towards a collaborative development of two or more actors. In these collaborative efforts, the crucial role of co-creation has to be emphasized (Bogers et al., 2010; Schuurman et al., 2015). As Schuurman (2015) describes, a living lab is "a tool for distributed innovation that drives co-creation between the different actors involved, while providing the user with a central role". Indeed, organizations want to utilize co-creation in order to tap into the knowledge of (end) users (Kristensson et al., 2008).

Følstad (2008) argues that, in order for users to provide valuable contributions to the innovation at hand, they need to be able to experiment with the innovation and ideally do so in a real-life context. Real-life experimentation is seen as a defining characteristic of living labs (Schuurman, 2015). Coorevits and Schuurman (2015) argue that innovation is unpredictable because of contextual factors, influencing the product usage during this real-life experimentation (Sein et al., 2011) and therefore the testing of products built in the front-end of design is crucial. Forlizzi and Ford (2000) also stress the importance of the context-of-use, which influences the interaction of the user with the innovation. Therefore, it is of utmost importance to provide users with ample opportunities to experiment with the innovation, at least in a familiar and preferably real-life context. It is here that living labs are different compared to other innovation methods (Niitamo et al., 2006; Schuurman & De Marez, 2012; Coorevits, 2015). Testing not only provides context-specific insights on the development and acceptance of the innovation, but also informs researchers and practitioners about the conditions of technology acceptance and the impact of the innovation on the society and on its environment (Frissen & Van Lieshout, 2004).

Towards B2B (B2B) Living Labs

Since 2009, imec.livinglabs (formerly known as iLab.o and iMinds Living Labs) has offered "living labs as a service" to reach its mission of facilitating digital innovation in Flanders, Belgium. The service offering of the imec.livinglabs is focused on confronting potential end users with innovations by small and medium-sized enterprises (SMEs) through co-creation and real-life experimentation. In order to succeed in this facilitation, a key asset of the imec.livinglabs organization is its B2C-focused panel of potential test users. The majority of these projects are based on bilateral agreements, with a project usually lasting three to six months. Table 1 shows the recent increase of B2B projects relative to B2C projects in the portfolio of the imec.livinglabs. Over the course of the organization's first five years (2009–2014), B2B projects accounted for less than 20% of all cases. Many innovations of SMEs in Flanders are in the B2B market, and while these innovations previously did not take into account the needs of business users, a shift in the market could be observed. imec.livinglabs reacted to this evolution by integrating business model expertise into its offering (see Rits et al., 2015). The positioning of living labs in the B2B market of imec.livinglabs proved successful as evidenced by the absolute increase in B2B projects and the shift in the proportion of B2B projects where more than half of recent projects were B2B oriented.

Table 1. Increasing proportion of B2B living lab cases at imec.livinglabs from 2009 to 2016

	B2B	B2C	Total	% B2B
First 5 years (2009–2014)	4	18	22	18%
Next 2 Years (2014–2016)	21	19	40	53%
Overall (2009–2016)	**25**	**37**	**62**	**40%**

This shift from B2C-oriented projects to B2B-oriented projects is important to investigate because of the different characteristics and needs of these two settings. In general, compared to B2C markets, B2B markets have a limited number of customers that generate the largest part of the revenue (Sheth et al., 2000). Thus, when compared to B2C, B2B transaction values tend to be larger and purchase cycles tend to be longer (Brennan et al., 2007; Griffin, 2001). Also, the markets feature different methods of interaction between the business and the client, with B2B traditionally favouring face-to-face interactions (Di Fiore, 2016). Thus, in new product development, a relatively small set of potential B2B customers can exert significant influence over a firm's innovation (Bonner & Walker, 2004). Moreover, the decision makers might not be the actual users of the innovation, which impact the open innovation process significantly. Given that top managers may play a crucial role in driving innovations (Tellis et al., 2009) and may determine the direction of the innovation, a different role needs to be attributed to different types of users. Abrell and colleagues (2016) argue that customers making the purchasing decisions can provide knowledge about short-term changes in market needs, whereas users working directly with the products provide long-term guidance for digital innovation. Looking at innovation, Castro (2015) states that B2B firms focus on internal processes and capabilities and product-mix innovations, whereas B2C firms innovate on the brand, presence, and customer experience. This difference affects which methodologies can be applied in this context. The application of real-life experimentation in B2B-oriented living lab projects poses methodological as well as practical challenges and implications for organizations offering living labs as a service, which have not been explored in the living lab literature.

The academic importance attributed to real-life testing and experimentation reinforces the need to assess such an approach in B2B-oriented living-labs-as-a-service projects. Although some authors (Ballon et al., 2005; Almirall et al., 2012) explicitly mention B2B living labs, no clear insights are provided on the application of real-life experimentation in these distinctive environments. Ballon and colleagues (2005), for example, make note of considerable differences in experimenting with innovations between B2B and B2C test and experimentation platforms (TEPs). However, they offer no guidelines on this matter. Further, Almirall, Lee, and Wareham (2012) report that most cases in the Catalan Living Labs are B2B projects. They also compare the general methodological approaches of four living lab intermediaries in terms of the act of user involvement, the interpretation of real-life contexts, and the public–private–partnerships. However, the specific methodological differences between B2C and B2B contexts are not discussed, nor are any guidelines provided in relation to that distinction.

Case Study: Eight B2B Living Labs

We used an exploratory action research approach (Davison et al., 2004). We selected eight cases that were executed by imec.livinglabs as part of their living lab as a service, which is tailored towards SMEs. To ensure reliability, relevance, and comparability, the cases were selected according following criteria: i) the living lab projects had to be completely finished, ii) the cases must have been carried out between 2012 and 2016, and iii) the cases must be of a B2B nature. A case study approach was selected due to the absence of a clear supporting theory (on B2B living labs) and the exploratory nature of the study, in which key variables and their relationship are under investigation (Eisenhardt, 1989; Yin, 2009).

We defined a five-point scale (Table 2) to measure the extent of user involvement in a B2B living lab context. We followed Følstad (2008) to differentiate between a familiar, semi-real context (Level 3) and a real-life context (Level 4). We defined Level 3 as testing without interacting with the entire ecosystem the product usually would operate in and it is thus not integrated with other processes. The familiar context can serve as an alternative to the real world by allowing greater balance between the threat of low ecological validity related to test labs and the uncontrollable aspect of field studies. In B2B environments, a familiar context might be a pilot or prototype environment wherein the real-life context is simulated as much as possible. Researchers often opt for the familiar context so they can maintain control over a selection of elements they want to investigate, such as pre-defined task execution to determine the learnability of an application.

The testing in Level 4 goes one step further: users interact with the innovation in a real-life setting. The entire ecosystem is involved and integration is included as well. In the context of B2C-oriented living labs, (end)users are confronted with technology in their everyday lives. In this situation, researchers cannot control the users' actions and the external elements influencing their behaviour. The real-life aspect of the test environment should provide the researcher with "unexpected" outcomes to improve the innovation (Sauer, 2013). As described by Almirall and colleagues (2012), "Real-life contexts are much more than a more realistic scenario for validating proposals; they form an arena where new meanings can emerge, tacit knowledge can be captured, and the whole ecosystem can be validated."

Table 2. Five levels of user involvement in a B2B-oriented living lab

Level	Extent of User Involvement
0	No user involvement
1	Users describe their needs in an exploratory manner
2	Users provide feedback after observing an innovation but do not interact with it
3	Users test an innovation in a familiar, semi-real context
4	Users test an innovation in their real-life context

Table 3 summarizes our eight B2B living lab cases, five of which featured real-life testing (Level 4) and one of which featured testing in a familiar environment (Level 3). Table 3 also indicates that, in four of the cases, a real-life test was not performed within the scope of the actual imec.livinglabs project. In these cases, the entrepreneur performed the real-life testing on their own. Here, the role of imec.livinglabs was limited to identifying potential testing cases and coaching the entrepreneur on the execution of the real-life test, and potentially also assisting with the analysis of the results.

Through a cross-case study, we identified three main B2B-specific barriers to real-life testing – process integration, technological complexity, and tester identification – as shown in Figure 1. Each barrier is described in greater detail in the subsections that follow, along with proposed solutions for overcoming these barriers.

Barrier 1: Process integration
When setting up a field study (e.g., in cases 4, 6, and 8), integration was required between the innovation and the existing processes in the companies. If integration is required, the company needs to make a larger commitment to adapt existing processes in the firm, and the IT department of the company will need to be included in the project, which leads to higher project

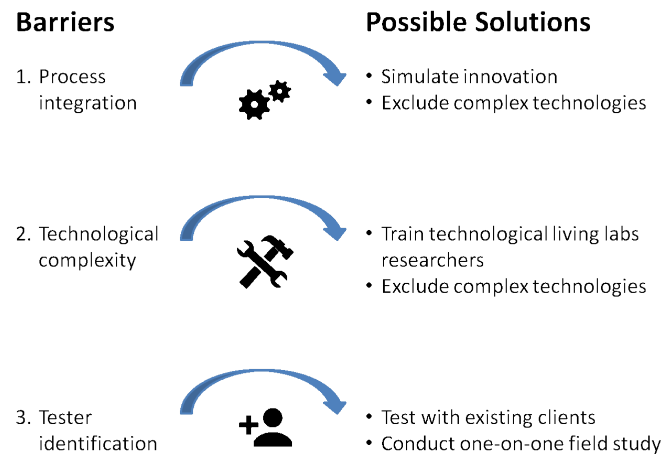

Figure 1. Three barriers to experimentation in B2B living labs and possible solutions

complexity. Nevertheless, in case 4, a proxy technology assessment was set up to simulate the technology through an alternative, simpler solution that could circumvent the difficult integration with existing procedures. A proxy technology assessment takes into account the context influencing the interaction of the user with the innovation in the front end of design and thus can provide an alternative to a field study early in the innovation process (Coorevits & Schuurman, 2015).

Table 3. Descriptions of the assessed cases of B2B living labs, their extent of user involvement, and the main testing entity

Case	Case Description	Extent of User Involvement	Testing Entity
1	A technology aiming to improve case management of processes in companies	Level 4	Entrepreneur
2	A startup focused on digital signage of content applications	Level 4	Entrepreneur
3	Improving the sourcing process by improving the information exchange between requestors, collaborators, and buyers	Level 4	imec.livinglabs
4	Coaching managers and employees on change	Level 3	imec.livinglabs
5	A solution to build, share, and manage knowledge in companies	Level 0	None
6	An Internet of Things (IoT) platform in a B2B context enabling companies to prototype IoT solutions	Level 4	Entrepreneur
7	A solution to track goods in the circular economy	Level 0	None
8	An integration layer for issue-tracking software	Level 4	Entrepreneur

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In cases where real-life testing proves to be difficult due integration with other processes, we argue that simulations of the innovation, such as proxy technology assessments, can help overcome this barrier to experimentation.

Barrier 2: Technological complexity

In cases 6 and 8, the technology was highly complex, as the target market involved IT professionals in different organizations. The user researchers did not have a deep background or expertise on these innovations, which made it difficult to understand the technical needs of the users. For that reason, it was too difficult to test the concept in a field study because the user researchers would encounter difficulties in being the translator between the designer and user. The complexity in both cases was linked to the need for integration, thus the barrier of technological complexity and the barrier of process integration (possibly) go hand in hand, but this aspect needs further research.

We argue that, to overcome the barrier to technological complexity, complicated technologies should either be excluded from testing in from B2B living labs or technical experts should be trained to perform experimentation in technologically complicated environments.

Barrier 3: Tester identification

The identification and selection of testers proved to be challenging in cases 3 and 6, and it prevented the inclusion of field studies in those projects. The difficulties in identifying B2B testers arose due to a smaller pool of potential testers. Thus, the recruitment of testers may be more resource intensive in B2B projects than in B2C projects.

This barrier can be overcome by utilizing existing clients of the entrepreneur, which might make the process of identifying testing entities more efficient. A living lab project can also be a starting point for another research project focusing on the field study in a one-on-one relationship between two research partners (the entrepreneur and their potential client), as was the shown in case 6. Alternatively, the living lab can coach the entrepreneur to perform the field study themselves.

Conclusion

In this study, we identified and proposed solutions to three specific barriers hindering experimentation in B2B living labs: i) process integration between the existing company processes and the innovation, ii) technological complexity of the innovation, and iii) limitations on the identification and selection of relevant testers. These identified barriers require careful consideration and operationalization of living labs in the context of B2B projects.

Next to overcoming these three barriers, we can first try to avoid them with a more rigid selection of B2B projects that are suitable for living labs. A living lab could, for example, solely accept B2B projects with ready-to-test user interfaces and exclude B2B projects focused on process integration. This living lab self-criticism on the potential of methodologies and formats for B2B projects deserves its own discussion.

Another avenue for further exploration is to identify a positioning of the living labs in cases where real-life tests are performed by the entrepreneurs themselves. The entrepreneur potentially lacks the expertise and experience to perform a real-life test and might not focus on the user aspects of the innovation. Therefore, the providers of living-labs-as-a-service can position themselves as coaches rather than actual implementers of the real-life tests.

Potentially, living labs can also explore the potential of a B2B-focused panel similar to the B2C panel utilized by imec.livinglabs. This approach would potentially improve the identification and selection of testers for B2B innovations.

In conclusion, we believe that overcoming the identified contextual barriers through the different solutions we proposed – and others to be identified in future research – real-life experimentation in B2B living labs can prove to be highly beneficial to the development of B2B innovations.

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Reflecting on Actions in Living Lab Research

Anna Ståhlbröst and Marita Holst

> *Follow effective action with quiet reflection. From the quiet reflection will come even more effective action.*
>
> Peter Drucker (1909–2005)
> Management consultant, educator, and author

Living labs deploy contemporary open and user-centred engagement processes in real-world contexts where all relevant stakeholders are involved and engaged with the endeavour to create and experiment with different innovations. The approach is evidently successful and builds on the perspective that people have a democratic right to have influence over changes that might affect them, such as those brought about by an innovation. In this article, we will reflect on and discuss a case in which end users took part in the development of a method that stimulates learning and adoption of digital innovations in their own homes while testing and interacting with it. The results show that, when end users were stimulated to use the implemented innovation through different explicit assignments, they both increased their understanding of the situation as well as changed their behaviour. Living lab processes are complex and dynamic, and we find that it is essential that a living lab have the capability to adjust its roles and actions. We argue that being reflective is beneficial for innovation process managers in living labs because it allows them to adjust processes in response to dynamic circumstances.

Introduction

The living lab approach builds, first and foremost, on the position that end users, or people being affected by the technology, are the only real experts regarding their own contexts, goals, and activities and therefore it yields important insights that are beneficial to innovation processes (Leminen & Westerlund, 2016; Schuurman et al., 2016). This approach is evidently successful and has resulted in new product features, new value propositions, and identification of bugs in systems; but, more importantly, it has enabled profound understanding of use contexts and the real-life benefits of innovations (Hakkarainen & Hyysalo, 2013; Ståhlbröst, 2013). It builds on the perspective that people have a democratic right to influence changes that might affect them as a result of an innovation (Bergvall-Kåreborn et al., 2014). The living lab approach is based on the notion that co-creative innovation processes are more effective and result in innovations that create value for their intended end users (Krogstie et al., 2013).

Earlier research has also shown that user participation positively contributes to the success of digital systems, especially in technically complex system (Lin & Shao, 2000). However, involving end users is not always a straight forward process because companies, at times, are reluctant to challenge their existing mode of operation even though they are faced with valuable input from end users (Hyysalo et al., 2016). In innovation processes, it is also rather common that different perceptions about the form and function of innovations lead to tensions and conflicts between stakeholders (Hakkarainen & Hyysalo, 2013). Adding to that, engineering as a field usually lacks the expertise on how to deal with unstructured human situations, and they have limited traditions in understanding the social context that is necessary to shape a digital innovation from a socio-technical perspective (Bilandzic & Venable, 2011). Hence, developing an innovation is not only a process of interaction and a struggle to develop “the right thing”, it is also a process of understanding, learning, and sharing among the involved stakeholders.

Reflecting on Actions in Living Lab Research

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So how can living labs ensure that the engaged end users have the opportunity to make their voice heard and influence innovation processes? And how can a living lab create a process that enhances learning and dialogue between end users and other stakeholders (e.g., problem owners, developers, or living lab practitioners) so that their interaction becomes fruitful for all stakeholders? Innovation process managers in living labs strive to balance the power relations between the different stakeholders– including developers, managers, policymakers, citizens, end users, and affectees – by helping them to both listen and be heard in innovation processes and by enabling them to have an actual impact on the innovation being developed (Bergvall-Kåreborn et al., 2015). To be able to do this, the potential end users or affectees need to be well equipped and have a sound understanding of the digital innovation being elaborated and tested; otherwise, their input may be of a general character or be based on (understandably) naïve assumptions and therefore may fail to have an actual impact. Hence, the aim of the research presented in this article is to reflect on and discuss a case in which end users took part in developing a method that stimulates learning and adoption of digital innovations in their own context while testing and interacting with it.

An Approach to Living Lab Research and Innovation

In research-oriented living labs, it is important to make a distinction between the innovation process and the research process even though they might be interwoven and hard to separate at times. In this article we draw upon our experiences with a particular case of a research-oriented living lab project, Apollon, which will be described in greater detail below. In the Apollon project, the research purpose was to develop a method that stimulated learning and adoption of innovations in the end users' private homes. The innovation process was focused on end users testing and providing insights related to the digital innovations they tested, for instance usability and usefulness issues (Ståhlbröst & Holst, 2016). In this article, we will report on the research process by reflecting on and discussing the effectiveness of the method being developed.

We have applied an action design research approach with the aim of learning from and contributing to both practice and research while being guided by the notion of reflection in action (Schön, 1991) and by participatory action design research (Bilandzic & Venable, 2011). Being a reflective researcher requires a commitment to learn from experience and evidence, rather than to learn a predetermined path of actions (McMahon, 1999). In living lab research, one vital approach is to be open to what is happening in the context and to adjust the process accordingly. It is therefore important that living lab researchers apply a reflection-in-action approach to their research and innovation processes. Related to the action design research approach, our aim in the case being referred to in this article was to test, evaluate, and re-design two digital innovations while informing theory (Sein et al., 2011). In living lab research processes, it is important to distinguish between the innovation process and the research process of reflecting and learning, where the former is related to the innovation as such while the latter is related to the research process and formalizing learning. Hence, living lab research needs to, in the same vein as action design research (Sein et al., 2011), relate problems arising in practice to classes of problems identified in theory and express the learnings in generalized outcomes. In this process, generalizations can be made on three levels (Sein et al., 2011): i) generalization of the problem instance, ii) generalization of the innovation instance, and iii) derivation of design principles for the type of innovation. Hence, the reflection and learning process extends from focusing on building a solution to applying learning to a broader research problem area.

In the case reported on in this article, we carried out continuous reflections on the interaction with the end users, the suitability of the used interaction and stimulation method, as well as the digital innovations´ inherent functionalities and its influence and suitability to contribute to end users' objectives. This process was designed to: i) increase knowledge on the design of end-user interaction processes that foster learning and understanding (i.e., the research) and ii) gain insights into problems related to the innovations as such (i.e., the innovation). In the reflective process, theoretical knowledge was applied onto the practical situation based on the researchers' focus, which in our case has been the use of assignments for end users to carry out in their context to stimulate both their learning and adoption of the innovation. Being a reflective practitioner means that the researcher approaches a practical situation as an exclusive state (Schön, 1991) In this approach, the researcher uses their prior experiences as a basis for their actions with the objective to discover and understand the unique characters of the situation and, based on that, defines the scope and process of the research actions. Based on the shaped problem, the researcher conducts experiments with the aim of discovering related effects and challenges. Being a reflective researcher and practitioner also means that unintended changes can be produced in the situation, which might give it new meanings. Hence, there is a constant interaction and reframing between the practitioner and the situation at hand going through the stages of appreciation, action, and re-appreciation. Hence, the understanding of the situation grows as we strive to change it, and it is then changed through our attempt to understand it (Heiskanen & Newman, 1997).

In our case, we also wanted the end users to adopt the technology. In general, technology adoption is a multidimensional process where an individual's behaviour is influenced by a variety of conditions. These conditions can be learning, social, and technological (MacVaugh & Schiavone, 2010). Learning conditions are individual characteristics of a single user and can be expected to influence the attainment of new competencies needed to use the new technology. Social conditions explain the cultural and relational specifies shared within the communities to which the user belongs. Technological conditions facilitate the explanation of technical features of the exchanging technology (MacVaugh & Schiavone, 2010). Naturally, the importance of each of these conditions differs depending on the context in which the innovation is intended to be used.

The Living Lab Case: Apollon

The living lab case referred to in this article was carried out as part of the Apollon project, which was financed by the European Commission. The case took place between December 2010 and February 2012. Today, the process of facilitating learning and adoption among end users in living lab processes remains an important and unsolved issue that may benefit from reflection on an established case. In addition, many living lab studies are carried out for a shorter period of time, usually a few weeks; hence, reflections and lessons learned from more longitudinal studies are important contributions to the area of living lab research. We have also applied the approach in more recent energy-saving projects, such as the Cassandra project carried out from 2012 to 2014 (Runardotter & Holst, 2014).

The living lab process used in the Apollon project was designed to stimulate knowledge creation and adoption of energy visualization technologies by users by providing them with assignments to carry out in their homes while they familiarized themselves with the technology and increased their understanding of different energy-saving approaches that they could apply in their homes. For this case, we recruited 20 households interested in testing energy visualization technologies while contributing to our research efforts. Ten of them tested a visualization technology called SABER, which measured and visualized real-time consumption of district heating, electricity, and cold and warm water over the course of seven months. The other ten tested a visualization technology called ELIQ, which measured and visualized real-time electricity consumption, again over seven months.

In this case, we applied a rather traditional living lab approach that focused on real-world tests of innovations with end users in their context. The innovations were quite mature and testing was possible in the end users' homes. In the follow up interviews, we did however add formative questions to find possible suggestions for improvements of the digital innovations. Hence, the innovation process did not focus on co-creation of innovations; rather the co-creative activities were related to the research process, such as the use of assignments and questions to increase the participants' understanding and knowledge.

After being recruited, the end users were given instructions and support in installing the digital innovations in their homes, which meant that we interacted with the end users in their homes and we used their input and reactions to continuously reflect on and redesign our study and to receive input to re-design the final solution. To support the test process, we wanted to have continuous and controlled interaction with the end users, so we developed a "test storyline", that is a detailed step-by-step process consisting of seven assignments and questions with clear instruction regarding how and when the assignments should be carried out. Each assignment was designed to be instructive and enable learning about the situation at hand, in this case energy consumption in the families who tested the technologies. When an assignment was to be carried out, a link to an online survey with clear instructions and fields where the end users could fill in their answers was sent to the end users by e-mail. From a research perspective, we wanted to learn how the assignments could be designed to be undertaken by end users on their own. We designed the assignments into micro-tasks that were functionality driven, small, well defined, and easy to perform. The goal was to stimulate usage of the different functions that each digital innovation offered. For example, an assignment could be formulated as follows:

1. For five days *before* installing your Christmas lights, make daily meter readings and enter the summarized readings in the designated field in the survey.

2. For five days *after* installing your Christmas lights, make daily meter readings and enter the summarized readings in the designated field in the survey. Turn your lights on or off as you wish during this period.

3. Then, install and configure timers to turn off your lights at night or when you are way from home. For five days after setting up the timers, make daily meter readings and enter the summarized readings in the designated field in the survey.

These assignments were then followed by questions related to the effect on the end user's consumption, such as the difference before and after installing the lights or the timers. We asked questions related to their experiences and thoughts about a given assignment, and whether they expected or were surprised by the results. We also asked whether they would consider making a change in behaviour based on what they learned. All the answers were gathered in the online survey. The results from the assignments showed that the end users testing the ELIQ technology had difficulties detecting meaningful differences in consumption because the outdoor temperature also influenced their electricity consumption during the days they made measurements. For example, on colder days, they naturally used more electricity to heat the house. This confounding factor made them reflect on what the ELIQ actually showed them and what conclusions they could draw from the visualization.

Focus group interview with test users

As a closing activity, we invited end users from all 20 of the case households to a group interview. The purpose was to support reflection on action regarding their experiences of the test and to facilitate learning from the process while at the same time receiving suggestions for re-designing the digital innovations. Seven end users joined the meeting and we interacted with them for almost two hours. Unfortunately, the event lacked gender diversity: all seven attendees were male. Most of the participants showed significant interest in energy and environmental issues, and some reported having these interest since childhood. The end users' joint interest in the topic made us reflect on user-recruitment criteria in cases that extend over a long period of time. Here, it is beneficial for living lab cases if the end users have a solid interest in the application area of the innovation because it can help keep them engaged through the whole test period and while carrying out assignments.

Another interesting reflection from this case was that the end users all reported having joined this living lab case quite spontaneously without involving their family in the decision to participate. This unilateral decision became a problem for them during the test period: the rest of their family were not as engaged in energy-saving activities, which led to a situation where the family fathers had to spend a lot of energy convincing their family members to make an effort and contribute to the test and energy savings in the household. Hence, taking part in real-world tests of innovations in the home might not be a one-person effort: it impacts the family as a whole, that is, the social system.

During the interview, we openly discussed the end users' experiences of being involved in this test process. In these discussions, the end users identified aspects related to the technology and its usability, such as problems in reading the visualization meter and knowing how much each appliance was consuming, for instance, when different electrical radiators turned on or off, or when the freezer turned on or off automatically. Hence, it was difficult for them to know if the difference in consumption was based on their effort in the short term or if it only was based on their appliances turning on and off in a different way. But, even if this was a problem, the end users stated that they learned a lot from the different assignments, from the reflections they had to do when performing them, and in answering the follow up questions.

The interviewed end users also stated that the assignments given to them in the test storyline made them reflect on their energy consumption in new ways, which in turn stimulated them to take actions to change their energy consumption. For example, most of them invested in low-energy lamps or LED lamps. Furthermore, they developed tendencies to turn off lamps when leaving a room, to connect appliances with transformers to sockets that can be turned off, and to using timers on some of their appliances.

Using the test storyline supported the living lab process of conducting long-term tests involving end users in their private context, where researchers have little or no control over the actions being carried out. The test storyline also supported the communication between the living lab and end users to make sure that they understood what was required from them during the test

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they volunteered to take part in so that they would not get any unwanted surprises and could be in control. The test storyline as a tool also ensured that end users developed a solid understanding of the innovation because it encouraged them to test all functionalities of the digital innovation while, at the same time, it stimulated learning and increased the competence of end users. Through this approach, the end users acquired knowledge on both energy-saving opportunities, they increased their level of competence in using the digital innovation, they provided competent feedback related to the design of the innovations, and they gave competent feedback on the living lab approach with the test storyline.

Reflecting on the Living Lab Approach

The aim of this article was to reflect on and discuss a living lab approach applied in a case aiming to stimulate understanding and adoption of digital innovations among end users in their homes. In this case, we implemented a test storyline consisting of a structured interaction plan with seven instructive assignments for the end users to carry out during the seven-month test period. The results from this case indicate that giving the end users assignments to carry out during the test was a successful way to stimulate use, increase learning, and foster understanding about the research area, in this case energy saving. Reflecting on what other field research methods, such as ethnography, might have been suitable due to the long-term perspective of the case, which continued over a seven-month period. A classic ethnographic study usually requires six months to two years (or more) in the field for the researchers to become acquainted with the context, the culture, and language within the context and its basic structure (Fetterman, 2010). In our case, this approach would have been too time consuming and would have posed problems with the extent of access to the end users' homes that would have been needed to obtain the required insights. Ethnographic studies usually collect data through observation (Fetterman, 2010), which in living lab cases becomes challenging due to the aim of involving and understanding a group of individual end users simultaneously. In addition, ethnographic studies do not have a design focus; rather, they focus on understanding, describing, and capturing social and cultural phenomena that might embody aspects relevant to designers (Bilandzic & Venable, 2011). Hence, living lab research has many similarities with ethnographic methods. But, researchers in living labs do not merely want to understand and observe a phenomenon; rather, their aim is to actively change a situation by implementing a digital innovation and by empowering end users with different means.

The results from this study also show that, when the end users were prompted to use the implemented innovation through different explicit assignments, they both increased their understanding of the situation (e.g., energy saving), as well as changed their energy consumption behaviour (e.g., lowered their energy consumption by approximately 10% over a one-year period). When it comes to energy consumption behaviour, it is not trivial to determine what the changes are dependent on in this living lab case. When it comes to end users changing their energy consumption behaviour, we know that feedback and visualization technologies are a positive influence (Darby, 2000; Seligman & Darley, 1977). Hence, in this research, we can only refer to the end users' testimonies that the performance of assignments educated and influenced them, not only the digital innovations (i.e., feedback and visualization technologies) as such. In addition, in this case, we measured energy consumption over a full year, which is a longer period than the specific seven month living lab case. The reason for this was to obtain comparable data between years. This data analysis is accounted for variations in outdoor temperature and wind conditions based on the established degree-day calculation method. Hence, we can conclude that the reduced energy consumption by end users reflects underlying changes in behaviour that are likely to persist over the long term.

Reflecting on the process of engagement in the case also raises the question of whether these results would had been reached if the tests had been carried out in a controlled laboratory setting. In this context, it would have been possible to observe how the end users interact with the technology and they could have given inputs on potential design changes of the digital innovations. In such a situation, the end users are providing feedback based on their immediate and intuitive understanding and thoughts related to the innovations as such, not based on their true use experiences. It has been argued in previous research (Yoo, 2010), that end users find it difficult to give relevant feedback on a digital innovation if they have no experience of actually using it. In addition, in a laboratory setting, it would not have been possible to study changes in behaviour related to actual use of the artefact. Hence, in processes where the aim is to reach a deep level of understanding and insights based on real-world experiences, and when a changed behaviour is a desired outcome, a living lab approach is useful.

In addition, the use of the test storyline that stimulated use of the digital innovation also helped the end user experiment with the digital innovation in a safe and comfortable context. Reflecting on this approach, we conclude that end users feel safe being guided by assignments in their homes; the guideance encouraged them to explore and be more acquainted with the innovation without anyone observing them and measuring their performance, which is a common approach in user tests in laboratory settings. Hence, the real-world context with educational assignments did strengthen the confidence of end users with the innovation and thus contributed to end users being better equipped to give valuable feedback on potential re-designs of the innovation. The end users also became aware of the innovations´ suitability for their specific context and goals, and this awareness contributed to their adoption of the artefact in relation to feelings of compatibility. Thus, they knew how to use the innovation and they understood how it answered their needs and existing values (Rogers, 1983). Another key aspect of the test storyline was that it regularly reminded the end users about the technology and encouraged them to use it. Hence, the likelihood for actual adoption of the technology increased as the innovation became a part of their social system.

Reflecting on the assignments reveals some drawbacks that need to be addressed in future studies. For instance, it can be difficult to determine whether the participants involved in the test actually performed the assignments even though they report having done so. To minimize the risk of false reporting, we strived to give them assignments where they had to enter values into the online survey, such as the exact consumption of electricity (KWh) over a specific period. Even so, it was difficult to know whether they had actually done it. Here we can see that research methods such as ethnography (Hammersley & Atkinson, 2007) could have increased the validity of the study. Another drawback with the living lab approach with test storylines is the scalability. In the experiment being studied in this research, we engaged 20 end users, which made it possible to reflect on their feedback during the design of assignments for the next period and co-creatively design them. We found that, even though the scale of the case was rather small, the findings and input gave us deep insights and understanding of the end users' situation and the challenges they faced during the test period. For instance, the end users could send an email when the digital innovation did not really work properly and they could be given technical support before continuing the test.

Conclusion

Living lab processes are complex, involving multiple stakeholders in real-life contexts. This complexity leads to processes that are difficult to predict given that the innovation, people, and challenges might move in new directions. Consequently, it is essential that a living lab has the capability to adjust their roles and actions accordingly (Hakkarainen & Hyysalo, 2016). We argue that living lab approaches benefit from applying a reflective stance. Being reflective is beneficial for innovation process managers in living labs because it enables them to adjust processes in response to changing circumstances. Living lab researchers benefits from reflective practices through their contributions to learning and theory. Furthermore, end users involved in living lab research and innovation processes also benefit from a reflective approach, both from the perspective that they are involved in an innovation process that fits into their everyday practices, but also because they can reflect on their own knowledge creation and learning from their involvement.

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Action Research as a Framework to Evaluate the Operations of a Living Lab

Sara Logghe and Dimitri Schuurman

> *"Seeking objective truth, the modern worldview makes no connection between knowledge and power. This positivist worldview has outlived its usefulness: as Habermas announced, 'modernism is dead'."*
>
> Peter Reason and Hilary Bradbury
> In *Handbook of Action Research* (2001)

In this article, we propose an action research approach to capture and act upon the delights and frustrations of panel members who participate in living lab research in order to optimize the operations of the living lab itself. We used this approach to test the effectiveness of action research in providing guidelines to practitioners to evaluate and design effective and sustainable user involvement processes in living labs. We conducted a focused literature review and an in-depth case study of both the integration of a researcher within the community and the implementation of an action research project within an existing living lab. This living lab is regarded as both a forerunner and a best-practice example in Europe. Based on our findings, we recommend co-creating the "operations" of a living lab with the users themselves following a combined action research and living lab approach.

Introduction

The fast pace of technological change and globalization – and the associated increase in access to knowledge – have enabled a growing number of users to engage in the innovation process. Companies, too, have sought out user contributions to their (new) products and services (Bogers et al., 2010). In addition, research has indicated that different kinds of users have different kinds of needs. People have a higher willingness to pay for a product or service that perfectly satisfies their personal needs (Franke & Piller, 2004). To develop these customized products or services, it is possible to let users adapt products themselves and thus become part of the innovation process itself (Franke & von Hippel, 2003).

Active end-user contribution is one of the building blocks of innovation processes in living labs. Living labs are public–private partnerships established to foster user-driven innovation and are supported by the European Commission through policy measures (Schuurman, 2015). Living lab research consists of user co-creation and experimentation of innovations in real-life contexts (Eriksson et al., 2005). The underlying idea is that people's ideas, experiences, and knowledge, as well as their daily needs for support from products, services, or applications, should be the starting point in innovation (Bergvall-Kåreborn & Ståhlbröst, 2009). The living lab approach is also a form of open innovation, because technology is developed and tested in a physical or virtual real-life context with multiple innovation stakeholders, and end users are important informants and co-creators during this process (Kusiak & Tang, 2006).

The efficiency of a living lab is based on the creative power of user communities. For this reason, it is important for the research activities and living lab operations to be aligned with the expectations of the participating users. Motivated users, willing to participate in research and co-creation activities, are essential for the functioning of a living lab, given that the underlying philosophy is that people's ideas, experiences, and knowledge, as well as their daily needs and wants, should be the starting point in innovation (Bergvall-Kåreborn & Ståhlbröst, 2009). However, in terms of the three layers within living lab activities (Schuurman, 2015; Schuurman et al., 2016), the input from users is

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collected at the micro level (living lab user involvement activities), but the panel management and strategy towards user involvement should be taken into account at the macro level of the living lab – meaning its internal organizational processes for coping with different living lab projects.

Although this active user involvement is regarded as essential, few studies have focused on the motivation, attrition, and behaviour of users in Living Labs (Baccarne et al., 2013; Logghe et al., 2014; Ståhlbröst & Bergvall-Kåreborn, 2011). Moreover, we are not aware of any literature that reports end-user involvement in the design of user activities and operations in living labs, although this might seem to be a logic step for living lab practitioners who regard active user involvement as cornerstone of the living lab philosophy. Therefore, within this study, users were empowered to participate in the design of living lab activities and operations – at the macro level (organization), rather than at the micro level (user activities). We propose action research as a method to iteratively capture and implement this feedback because it emerges over time in an evolutionary process, as individuals develop skills of inquiry, and as communities of inquiry develop within communities of practice. This process not only leads to new practical knowledge, but also to new abilities to create knowledge (Reason & Bradbury, 2001).

Therefore, as a first part of this article, we examined the literature on action research for frameworks that could guide this process of user involvement. Within a participatory action research process, "communities of inquiry and action evolve and address questions and issues that are significant for those who participate as co-researchers" (Reason & Bradbury, 2008). Contrary to other research methods, action research does not emphasize disinterested researchers and reproducibility of findings. Among others, Ståhlbröst (2008) has already used action research as a methodology within a living lab environment to involve users early and throughout the whole development process, including the design of new information technology systems based on these users' needs. What is not dealt with in the literature is how this research approach can be used to construct a framework for user involvement and participation in the construction and optimization of living lab operations.

This aspect is addressed in the second part of this article; following our review of the literature on action research, we put the selected frameworks to the test in a single case study carried out at imec.livinglabs (imec-int.com/en/livinglabs; previously iMinds Living Labs). The first step of our implementation of action research was to gain knowledge about the current situation, meaning we sought to identify the basis for the organization's desire to change or alter its behaviour (Baskerville & Pries-Heje, 1999). After six years of living lab research at imec.livinglabs, many of the operation processes have changed. Following Ståhlbröst (2008), we started our action research approach by describing a main research theme within imec.livinglabs: to get to know the delights and frustrations of our panel members regarding their participation in living lab projects. In order to answer this research question, a user researcher from imec.livinglabs became a panel member within specific living lab projects. Thus, our case study uses action research as a method to involve panel members in the organization processes of a living lab. We conclude the article by drawing main conclusions and recommendations on the use of action research in living labs.

Action Research in Living Labs

Lewin (1946) first described action research as "comparative research on the conditions and effects of various forms of social action and research leading to social action" that uses "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action". Action research has become an established research method that is often used in social sciences, but it is now used to not only to build knowledge on a certain topic but also to bring about changes to the topic. In order to stimulate these changes, several authors suggest that the researcher should become part of the user panel so that the obtained knowledge can be immediately applied (Baskerville, 1999). Furthermore, Checkland and Holwell (1998) distinguish three main phases of the process of action research: i) the researcher enters a real-world situation, ii) actions begin, and iii) the researcher leaves the situation and reflects on it in order to find a variety of lessons learned (Checkland & Holwell, 1998; Rönnerman, 2004). Because of its foundation in practical action and its aim to solve an immediate problem while informing theory, action research is seen to produce highly relevant results (Ståhlbröst, 2008).

Action research starts with a practical problem owned by a certain group of people. The aim of this methodology is to find a solution for this problem, but also to develop theoretical knowledge for the wider research community (Chiasson et al., 2009). It requires understanding the context of the field and bringing changes to a current situation in order to solve certain problems through collaboration (Donnelly & O'Keeffe, 2013). Therefore, action research – and especially participatory action research – is also associated with the tradition of citizen science (Hand, 2010), wherein "the crowd" participates in scientific data collection and processing. Next to solving the specific practical problem, this research approach is mostly used to facilitate the understanding of complex human processes, rather than constructing universal social laws (Baskerville, 1999). It is particularly relevant when trying to "solve an identified class of problems" and producing guidelines for best practice (Sein et al., 2011). Reason and Bradbury (2001) argue that the characteristics of action research lead to a more valid research output because the practical and theoretical outcomes of the research process are grounded in the perspective and interests of those immediately concerned (in this study, the living lab panel members), and they are not filtered through an outside researcher's preconceptions and interests – a process that normally characterizes the positivist research approach.

The action research methodology and the living lab approach both appear to be user-centric research approaches, although the former has been used from the starting point (Lewis, 1946) in social research contexts and the latter has been used in technology innovation contexts. Compared to living lab research, action research fails to sufficiently empower users for co-creation in open development environments. As mentioned, action research has already been used in living lab research (Ståhlbröst, 2008), but mainly as a method on a meso (project) or micro (user activities) level, to gather insights during a living lab *project* by means of the different *user activities.* In this study, we used the framework of Ståhlbröst (2008) as a starting point for our research on the satisfaction and motivation of our panel members regarding their participation in living lab projects in general, which is part of the general operations of the living lab *organization,* or the macro level.

Previous research has shown that intrinsic motivation is very important for users to remain part of a living lab community (Baccarne et al., 2013; Ståhlbröst & Bergvall-Kåreborn, 2011). Not only are users empowered by living labs (Veeckman et al., 2013), living labs are dependent on the involvement and motivation of their participating users. It is not easy for living lab researchers to motivate possible end users to take part in their research activities (Logghe et al., 2014) and to retain them. Action research "seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities" (Reason & Bradbury, 2001). Thus, we decided to use action research as a framework to co-create policies and guidelines for long-term user involvement in living labs, and to validate and implement them through a case study of a particular living lab.

However, despite the advantages described above, action research is not without criticism in the literature. In our literature review, we identified three main areas of criticism of action research:

1. Because of the fact that a researcher becomes part of the study, a more personal view can become dominant during observations and deductions (Donnelly & O'Keeffe, 2013; Baskerville & Pries-Heje, 1999; Baskerville & Wood-Harper, 1996).

2. There is a lack of a common theoretical description of action research, which results in various approaches to action research (Chiasson et al., 2009; Donnelly and O'Keeffe, 2013).

3. The results of an action research setup are very specific, which may cause action research to simply result in more action research (Baskerville & Wood-Harper, 1996; Donnelly & O'Keeffe, 2013).

During our action research process, we took these valid criticisms into account and tried to establish reliability and validity for action research as a useful framework for researching living lab operations. Therefore, we tried to take into account each criticism as follows:

1. In order to avoid injecting our personal views, we asked questions in different ways. In this way, we were able to detect certain needs that were mentioned after asking various questions.

2. We compared different descriptions and implementations of action research in order to deduct one consistent theoretical framework for our use cases.

3. We selected multiple projects to implement action research in order to detect needs on a meso level rather than on a micro level. In this way, we tried to avoid to specific insights in order to gather more general results.

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Case Study

Case description, methodology, and overall process

The case focused on three living lab projects conducted at imec.livinglabs (imec-int.com/en/livinglabs; previously iMinds Living Labs), the living lab division of the research institute imec. Based in Ghent, Belgium, the former iMinds research institute became a separate business unit of imec following their merger in October 2016. The organization's experience conducting living labs dates back to 2009, with a particular emphasis on projects for startups and SMEs. imec.livinglabs has its own group of users (about 18,000 panel members or users) who are invited to participate in its living lab projects. For every living lab project, these panel members are invited to become part of a project community. In this way, they belong to innovation communities hosted by a neutral actor, in this case imec.livinglabs. These panel members cooperate as private participants during their spare time. But, according to Ståhlbröst and Bergvall-Kåreborn (2011), it is not sufficient to merely implement an innovation community in an organization to make a user innovation approach successful: it is also important to take into account what motivates the panel members to be part of this community.

In order to understand these motivations from an action research point of view, the main author of this article (an imec.livinglabs researcher) became a panel member from March 2015 until April 2016 and took part in different research steps in three living lab projects:

1. De Kopploeg (8 months): a living lab project focusing on online privacy issues

2. We Run (2 months): a living lab project about an application for runners

3. Spott (7 months): a living lab project about a new way to buy products with your smartphone you see during a TV show or TV commercial

These living lab projects were selected because they lasted for several months (so we were able to gather enough data) and consisted of multiple research steps (so we were able to ask the same questions in different ways). These three projects were also the first projects within imec.livinglabs whereby we focused on community building as a considerable aspect of a living lab. This approach fits with the aspects of action research of doing research in communities and emphasizing participation and action. Every community was inquired about in a collective way. The researcher became a member of the panel member community in order to experience the main motivations and thresholds for people to become and remain a panel member in a more intense way. The imec.livinglabs panel members of these three living lab projects were invited to give feedback on the general operation of imec.livinglabs by means of a survey (299 participants) and two co-creation session (12 and 8 participants, respectively. This allowed us to compare the experience of the researcher relative to the other imec.livinglabs panel members.

The goal of the survey (n=299) was to evaluate the experience of the panel members with the De Kopploeg living lab project. This survey resulted in insights on how to manage expectations from the panel members regarding a living lab project, on how to keep a panel engaged throughout the research track (short term vs. long term), and on how to keep the most active members engaged or involved during a research project. This was also the first living lab project where imec.livinglabs used a Facebook group to stimulate a community feeling between the panel members who joined this project. In the Facebook group, imec.livinglabs was able to collect reactions on certain statements from the survey, or the panel members asked both practical and substantive questions in this group and answered each other's questions faster than imec.livinglab coworkers were able to do so. imec.livinglabs was able to apply the main insights on the use of a Facebook group to the two other living lab projects under study.

In order to reflect on the involvement of researchers and panel members (Baskerville & Pries-Heje, 1999; Checkland & Holwell, 1998), we organized a survey and invited experienced panel members from each imec.livinglabs persona type (Logghe et al., 2015) to co-creation sessions to create solutions for the current frustrations of our panel members. Each co-creation session included the creation of a mock-up of the most interesting solutions. These mock-ups were validated by means of a specific validation survey and were handed over to the imec.livinglabs Marketing and Communication team who are currently constructing the community platform to be used over all living lab projects.

In December 2016, a final session was organized to ask our panel members for feedback regarding the platform in order to give our panel members the possibility to give an indication about what features or aspects

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should be modified before the final launch of the community platform. Based on these final remarks, a static version of the platform is being created and will be launched in March 2017. By inviting experienced panel members to these co-creation sessions, they became part of the reflection process on the operations of imec.livinglabs. In this way, learning occurs as an ongoing process in our research while reflecting on the method and projects as a whole (Ståhlbröst, 2008).

Findings

As a researcher who becomes a panel member, it is important to separate the application of knowledge to a project from the derivation of knowledge from each case (Ståhlbröst, 2008). As an example, we used the outcomes from "De Kopploeg", where we saw that a blog did not add value and that a Facebook group was consulted frequently, to plan the community strategy for the "We Run" and "Spott" projects. We also tested and implemented other measures such as a more personal communication approach (including names and photos of the panel managers in the communication), a higher "fun factor" in the incentives (personal challenges were used as "prize questions") and a faster, clearer feedback loop (creating infographics that summarize the user contributions from the research activity). We were able to capture this input during the project because the researcher took part in actions (research steps) in the situation (research projects) and acted upon it on an iterative basis for the subsequent projects. Also, through being a panel member and having conversations with other panel members, we found out that the imec.livinglabs panel has multiple unfulfilled needs and wants:

- They want more detailed information about the initiator of our living lab projects.

- They want more detailed results than they receive now.

- They need an overview of all the calls for research participation. They want to be able to look back at a finished project and ask: What was it about? What research steps were organized? In which research steps did I participate?

During these reflective co-creation sessions, we found the following underlying needs and wants:

1. Panel members want to define their role in the innovation process more explicitly.

2. They expect that the innovation will be implemented according to their inputs and feedback.

3. They accept that they are co-creating and experimenting with innovations that are not yet finished.

Based on these needs and wants, the panel members were asked to think about ways to address them. First, they indicated that it would be useful to have the opportunity to consult an online platform with a project flow for each living lab research project indicating in which research step users are needed and what will happen with their input. Second, they asked for more concrete follow-up information. Nowadays, panel members receive an infographic via email with the main conclusions of a research activity, but they want to receive a more detailed report with extensive findings. They want to consult this report online and not via email. Also, they want to receive more information about the final product when the research project is finished, including (where possible) a link to the app store or a newsletter of the company who created the innovation. Eventually, these sessions resulted in mock-ups of an imec.livinglabs community platform for panel members, which would provide the required information. At the end of the co-creation sessions, the participating panel members told us they felt appreciated because they were involved in a feedback moment regarding the living lab operations.

Discussion and Conclusion

In our study, we found it useful to have a researcher becoming a panel member and to directly gather feedback from panel members using more traditional methods (i.e., a survey and co-creation sessions). By combining living lab activities with an action research methodology, we were able to quickly gathering issues and frustrations on the one hand and rapidly co-create and implement practical solutions on the other. The added value of a researcher being part of the panel was the fact that the researcher was able to elucidate the results and put the insights into perspective. In this way, the action research methodology shed light on the differences between what people say and what people do (van Merrienboer, 2015).

Moreover, by means of a case study, we illustrated that the end users themselves can also be part of this action research process, which dealt with the question of how to improve the operations of a living lab. We facilitated the reflection process of panel members by adding a re-

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searcher as participant, which ensured that the researcher was completely socialized in the role of test user and attained a deep level of understanding of the current needs and wants of panel members while also lowering the threshold for end users to reflect and give feedback freely. Moreover, this approach also allowed for quick testing and evaluation of new approaches and solutions with panel members. In this way, imec.livinglabs decided to stick to a Facebook group to keep the panel members aware of the living lab projects.

In other words, adopting action research as a framework to evaluate and improve the operations of our living lab yielded positive results.

A major take-away was the fact that the action research approach and the living lab methodology strengthened and reinforced each other: the action research allowed us to uncover needs and wants with regards to user involvement in living lab projects and made it easier to experiment with new ways of involvement, which in turn enhanced the quality of the living lab research itself as the panel members felt empowered and involved in the living lab activities.

However, action research also has some caveats: as an action researcher, it is tempting to try to "act" like one of the regular panel members (Baskerville & Pries-Heje, 1999; Baskerville & Wood-Harper, 1996; Donnelly & O'Keeffe, 2013). The action researcher must stay more or less impartial in this situation and try to avoid pushing other panel members towards their own delights, frustrations, or solutions. They must also try to make other panel members feel at ease when giving feedback. Equally, we found that it was very useful to take the various criticisms into account during the research period, although it was not always easy to note down every insight in a structured way. Therefore, we propose to conduct further research leading to a more detailed framework about methods to use during the "practical part" of the action research process. Moreover, the long-term effects of involving panel members in improving the operations of a living lab on their motivation to participate should also be investigated.

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Keywords: action research, participatory action research, panel management, user research, living lab

Needsfinding in Living Labs: A Structured Research Approach

Louise Savelkoul and Murk Peutz

> *Cycling is possibly the greatest and most pleasurable form of transport ever invented. It's like walking only with one-tenth of the effort. Ride through a city and you can understand its geography in a way that no motorist, contained by one-way signs and traffic jams, will ever be able to. You can whiz from one side to the other in minutes. You can overtake $250,000 sports cars that are going nowhere fast. You can park pretty much anywhere. It truly is one of the greatest feelings of freedom one can have in a metropolitan environment. It's amazing you can feel this free in a modern city.*
>
> Daniel Pemberton
> In *The Book of Idle Pleasures*

Living labs enable innovations to be facilitated and implemented quickly and efficiently. A key element of the living lab approach is the active involvement of users. In this article, we examine a structured needsfinding phase of a living lab infrastructure project within the context of bicycle commuting. Given that effectuation costs are high, it is essential for the lab to focus on tackling the right user needs. Thus, the living lab's needsfinding phase aims to identify user needs and wants, as measured by bicycle commuting intention. We examined intention in a structured way by following the theory of planned behaviour. The results show that bicycle commuting intention can be explained by the variables of our model (R square=0.808). The specific insights arising from the needsfinding phase are an important focus for the activities and experiments in the later phases of the living lab. The generalized insights are also relevant to innovation experts outside the area of cycling.

Introduction

Promoting cycling is increasingly considered as a solution for complex mobility problems. However, there is relatively scarce research available about the motivations of bicycle commuters and their needs. Cycling differs from other means of transport and therefore existing large bodies of scientific literature can only be used indirectly (Harms et al., 2014; Wardman et al., 1997). For example, weather and physical effort have more impact on cyclists than on other means of transport. However, a large part of the decision to cycle can be explained by personal factors, allowing the use of more commonly used psychological models (Titze et al., 2008).

This article shares insights from a living lab in the Netherlands that focused on the personal factors influencing bicycle commuting intention. Partners from academia, government, and business wished to identify and understand the needs and requirements of cyclists and potential cyclists. A particular focus was "fast cycling routes", which are routes built to solve the problem of traffic congestion and as an opportunity for organizations to encourage more employees to commute by bike. For this reason, the living lab was called the Living Lab Fast Cycling Routes. A related topic of interest was the availability of electric bicycles (e-bikes), which contribute to this development by expanding the practical commuting range, enabling even more people to consider commuting to work by bicycle.

This article elaborates on the first phase of the living lab: the needsfinding phase. The needsfinding process is developed to "frame" the needs, goals, and values of (prospective) bicycle commuters, their employers, and other stakeholders. This article focuses on the needsfinding phase because it may yield interesting outcomes for the other phases of the living lab and for other living labs in general.

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The living lab approach has its origins in the experimentation with technology together with users (Niitamo et al., 2006). Whereas it is quite easy to change information quickly and cheaply, this is not the case for infrastructure projects. Furthermore, transport infrastructure projects often do not perform as promised; cost escalations appear to be the rule rather than the exception (Flyvbjerg et al., 2003). The structured focus in the beginning of the living lab is needed because of the high investment costs for this infrastructure project. Outcomes from a freeform living lab method could easily become too expensive to implement in terms of the required infrastructure. By using a structured method, costs are kept to the minimum as the users' wants and needs are measured in a structured way before the roads are being built. Hence, the users' needs and wants are implemented right away and roads do not have to be adjusted at high cost after construction.

The way to integrate this structured approach into the user involvement of the living lab is by a combination of a questionnaire, interviews, and focus group activities. Structuring the needsfinding process in this way makes it easier to respond to the needs of the users in later phases and contributes to a successful living lab. This approach is in line with the lean startup methodology, which suggests that, by validating hypotheses of customer's problems, startups find a solution that indicates there is business potential in solving the problem (Hokkanen et al., 2016). In this living lab, customer's needs and wants are also incorporated before the project/product has its final form.

The needsfinding phase has several steps that follow a logical sequence:

1. Identify technology, incentives, methods, and facilities through survey questionnaires, exploratory interviews, literature reviews, and research at the bicycle highway.

2. Triangulate the data from the questionnaires with other studies.

3. Prioritize the user problems on the basis of effects and costs in later phases.

4. Strengthen selected priorities with interviews and expert sessions.

In this article, we describe how this needsfinding phase was grounded in the theory of planned behaviour to predict bicycle commuting intention in the living lab. In the next section, we outline the theory and show how it was applied to the living lab case. Then, we present our specific methodology and results. Finally, we conclude with a discussion of these results and explore avenues for future research.

The Theory of Planned Behaviour

The theory of planned behaviour has been widely applied for predicting behavioural intention. In applying this theory, the personal motivational factors of individuals are used as determinants for the likelihood of expressing a specific behaviour (Glanz et al., 2008). Thus, the theory is useful in situations where it is not possible or practical to measure actual behaviour. It has strong predictive power, meaning that behavioural intention predicts actual behaviour (Ajzen, 1991; Armitage & Conner, 2001; Conner & Armitage, 1998; Sheppard et al., 1988). Although the theory is often used to predict health-related behaviour and exercise behaviour (Smith et al., 2007), it can be used for other types of behaviour as well.

Behavioural intention can be seen as the willingness of a person to perform a certain behaviour (Fishbein & Ajzen, 2011). The underlying idea is that behavioural intention encompasses the subjective probability that a person will perform a certain behaviour (Ajzen, 1991). In the current study, the theory of planned behaviour was selected to measure bicycle commuting intention. A positive bicycle commuting intention means that a commuter intends to cycle to work instead of using another means of transport.

The theory of planned behaviour comprises three independent variables that can explain the dependent variable of behavioural intention: i) attitude, ii) subjective norms, and iii) perceived behavioural control. These variables are related to each other in explaining behavioural intention (Fishbein & Ajzen, 2011), but depending on the case, only one or two variables may be important (Ajzen, 1991). Figure 1 describes the model and shows the relationships between the three variables, which are described in greater detail below, including how they apply to the context of bicycle commuting intention:

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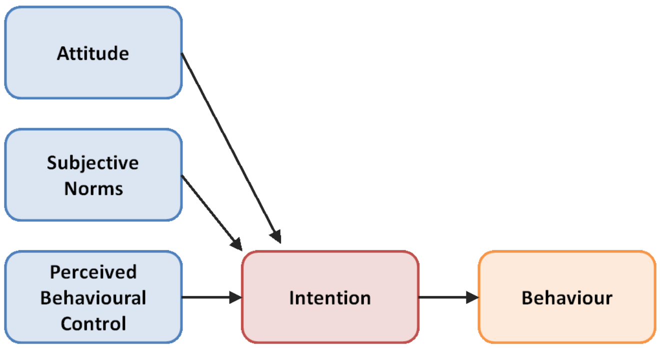

Figure 1. General model underpinning the theory of planned behaviour (Ajzen, 1991)

1. *Attitude:* this variable encompasses an individual's idea of the consequences of the behaviour and its importance to the individual (Ajzen, 1991; Fishbein & Ajzen, 2011). In the Netherlands, the attitudes regarding cycling are relatively positive compared to other nations: cycling is part of the Dutch way of living (Harms et al., 2014). A positive cycling attitude increases the likelihood of commuting by bicycle (Dill & Voros, 2008), and given that cycling levels are so high in the Netherlands, we expect that this positive attitude will lead to a high bicycle commuting intention.

2. *Subjective norms:* this variable refers to social pressure applied by others (Ajzen, 1991). It differs from attitude in that it focuses on the perception of pressure from the (social) environment instead of the personal perception of the behaviour (Glanz et al., 2008). Within the context of cycling, it is expected that bicycle commuting intention will be determined by an individual's family, friends and colleagues as they create a norm for cycling behaviour (Terry & Hogg, 1996). For this reason, we expect that high subjective norms will lead to high bicycle commuting intention. Respondents were also asked how important the pressure from family/friends and colleagues was for them.

3. *Perceived behavioural control:* this variable refers to the belief that a person has control over a specific behaviour (Francis et al., 2004). A difference can be made between internal and external control (Manstead & Eekelen, 1998), where internal control reflects the skills and capabilities of individuals (e.g., motivation and ability) and external control focuses on the available resources and difficulty of the task (Manstead & Eekelen, 1998; Terry, 1993). We expect that greater perceived behavioural control will lead to higher behavioural intention.

Added variables to account for contextual factors
Although the theory of planned behaviour is a valid and often used method for explaining behavioural intention, it only includes personal factors (Glanz et al., 2008). Within the living lab under study here, the user needs and wants are a central element. It is therefore necessary for our model to also include variables relating to the employees' organizational context. In the context of cycling, contextual factors play a large role. For example, Buehler (2012) has demonstrated that bicycle parking, cyclist showers and free car parking are determinants of cycling to work. It seems that the bicycle infrastructure of organizations and the bicycling incentives play a facilitating role in behavioural intention (Chatterjee et al., 2013). Accordingly, we added two variables to the conceptual model, as shown in Figure 2:

4. *Facilitating conditions:* Perceived facilitating conditions refer to individual beliefs about infrastructures that can remove barriers to the use of a system or can support its use (Venkatesh et al., 2008; Venkatesh et al., 2003). Therefore, it is relevant to consider employees' *perceptions* of the facilities available at their workplaces rather than simply documenting what facilities are actually available. In particular, we expect that bicycle facilitating conditions will have a positive effect on bicycle commuting intention.

5. *Incentive systems:* This variable can be described as the variety of incentives that organizations offer to their employees, such as financial incentives for buying or riding a bicycle (e.g., compensation for every kilometre cycled) (Heinen, 2011; Knoke, 1988). The growing interest in financial incentives for promoting cycling reflects findings that incentives are effective, even to the extent that they can almost double cycling levels (Dickinson et al., 2003; Handy & Xing, 2011; Wardman et al., 1997). For this reason, we expect bicycling-related incentives to have a positive influence on bicycle commuting intention.

Methodology

Bicycle commuting intention was measured by investigating three organizations in the vicinity of a "fast cycling route" in the Netherlands. The participating organizations were selected on the basis of their location but have different characteristics (public and private) and are from different sectors (healthcare, education, and industry). Employees of these organizations completed a questionnaire by which we measured their bicycle commuting intention. The study had a cross-sectional design. Before the actual questionnaire was

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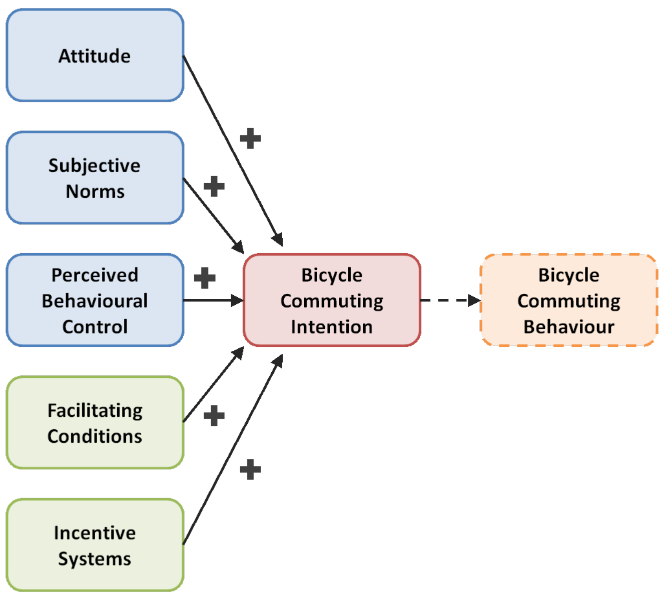

Figure 2. Conceptual model with added variables

sent to the participating organizations, it was sent to a pre-test organization and the feedback was incorporated into the final questionnaire. Only employees who lived within 30 kilometres of their workplace received the questionnaire. This distance was chosen to reflect a maximum commuting distance that would be practical by (electric) bicycle.

The gathering of data was part of the first step in the needsfinding, as described earlier. The bounded population included 3998 employees from the organizations under study. It was not necessary to do further sampling because everyone within the distance of 30 kilometres could fill in the questionnaire (convenience sampling). The questionnaire was based on literature sources measuring the variables of the theory of planned behaviour and the contextual variables and from questionnaires designed to evaluate bicycle commuting. A unipolar scale with five response categories was used because it has been shown to be valid for measuring behavioural intention (Thomas et al., 2004).

Data measurement and analysis

To measure bicycle commuting intention, multiple questions should be included (Ajzen, 2002). We included questions that followed Gibbons' (2005) splitting of behavioural intention into subdimensions to better predict actual behaviour: implementation intentions (planning behaviour), behavioural expectations (predicting behaviour), and behavioural willingness (openness to risk).

Attitude was measured according to the sub-items "direct benefit", "awareness", and "safety". To ensure validity, confirmatory principal component analysis (PCA) was performed on the nine items of attitude. The pattern matrix showed that the component "safety" was part of the component "direct benefit" and was therefore subsequently combined within it. This led to the following distribution of items: i) direct benefit including comfortability, lifestyle, pleasant/nice, time saving, and safety and ii) awareness including health benefits, cost saving, environmental benefits, and pleasantness.

Subjective norms were measured separately by normative beliefs and importance. PCA showed that the components differed from Heinen (2011). But, because the measurement of Heinen (2011) had a clear distribution (colleagues, family and friends), her distribution was used.

Perceived behavioural control was measured by two internal control items (confidence and trust) and one external control variable (constraint).

Facilitating conditions included questions about bicycle facilities and other facilities. The participating organizations' incentive systems were measured by financial incentives; other incentives were excluded due to insufficient correlation.

The following control variables were taken into account: gender, age, working hours, physical condition, car ownership, household structure, distance to work, luggage, frequency of past behaviour, and organization. Dummy variables were made for the control variables household structure (household structure 3 is the reference category), time block (multiple answers possible), and organization (company A is the reference category).

Missing values and outliers were checked and negatively formulated items were reversed. Thereafter, PCA was performed along with descriptive statistical analyses. Next, multiple hierarchical regression analyses were performed (see Appendix 1). For reasons of brevity, the control variables are presented only once without independent variables (model 1). First, the variables associated with the theory of planned behaviour were measured in total (model 2). Thereafter, the variables were separately measured (models 3, 4, and 5). Then, the contextual variables were measured (models 6 and 7). Model 8 includes all the independent variables. The additional multiple regressions for the three variables are included in models 9, 10, and 11.

Results

Multiple regression and hypothesis testing
We received 647 successfully completed questionnaires, which corresponds to a 16% response rate. Missing values were excluded pairwise. There were no striking outliers. Checks were carried out to ensure a sample size large enough for multicollinearity and singularity, distribution normality, linearity, homoscedasticity, and outliers. All the assumptions were met. Only the Mahalonobis distance was exceeded when outliers were checked. However, because the Cook distance was less than 1, there was no need to delete cases. Therefore, multiple regressions were appropriate.

The model including all the variables had an R square of 0.808 which is extremely high for testing the model of the theory of planned behaviour. Even without the contextual variables, the R square was still 0.807. Meta-analyses have shown that the explaining variance of behavioural intention by use of the theory of planned behaviour normally lies between 40% and 50% (Sutton, 1998). The high explaining variance means that this theory is a valid way to measure bicycle commuting intention.

The standardized coefficients were used to compare the contributing variables of bicycle commuting intention.

Variables
Appendix 1 shows the findings of the multiple regression analyses, which are summarized in Table 1.

Attitude had a statistically significant impact on bicycle commuting intention F Change (2.567)=49.203, p<.001. The dimensions of attitude were also tested. The dimension “awareness” did not have a significant effect on bicycle commuting intention, whereas the dimension “direct benefit” had a significant beta value (0.298, p<0.001).

The findings show that, for the variable *subjective norms,* only family had a significant contribution to bicycle commuting intention (bfamily=0.231, p<0.001). Importance of subjective norms did not have a significant contribution to bicycle commuting intention.

Perceived behavioural control had a significant impact on bicycle commuting intention. The contribution of perceived behavioural control is large in comparison to the other two variables.

For *facilitating conditions,* the R square changes from 0.713 to 0.714 (see model 6) but the change is not significant F change (2.595)=0.683, p>0.05).

Concerning *incentive systems,* only financial incentives of the organization were incorporated in the multiple regression. Financial incentives explained an additional two percent of variance in bicycle commuting intention but not a significant level F change (1.596)=3.240, p>0.05).

The control variable *past behaviour* had a significant influence on bicycle commuting intention in all models.

Table 1. Observed effects of variables and sub-items on bicycle commuting intention

Variable	Observed Effect	Significance	Conclusion
Attitude	Positive	Direct benefit significant, awareness not significant	Partially confirmed
Subjective norms	Positive	Subjective norms significant, importance not significant	Partially confirmed
Perceived behavioural control	Positive	Significant	Confirmed
Facilitating conditions	Negative	Not significant	Rejected
Incentive systems	Positive	Not Significant	Rejected
Past behaviour	Positive	Significant	Control variable

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Discussion and Conclusion

The ultimate goal of the living lab "Fast Cycling Routes" is to encourage cycling among employees of organizations in close proximity of fast cycling routes. This goal is aligned with the intention of the Dutch government's to build 675 kilometres of fast cycling routes by 2025. But, enabling new physical infrastructure to be built will by itself not lead to more cycling. The intention to use it must be understood and addressed.

This research demonstrates that applying a structured approach as part of the needsfinding phase is promising. This research confirms by its high explaining variance that the model derived from the theory of planned behaviour is a valid way to research behavioural intention (R square = 0.808). The study builds upon earlier work regarding bicycle commuting intention and extends it with a combination of personal and contextual factors. Earlier work concentrated on either personal factors or contextual factors. Therefore, a more comprehensive overview of bicycle commuting intention is achieved by combining these factors into one study. One explanation for why the results for facilitating conditions and financial bicycle incentives (the contextual variables) were not significant could be because perceived conditions were measured instead of actual facilities and incentives. Future applied research could elaborate further on these results to understand if this explanation is appropriate.

Furthermore, this research shows that for the development of fast cycling routes, a personal or psychographic factor should be included (e.g., perceived behavioural control, subjective norms of the family, or the attitude dimension direct benefit). This means that the intrinsic drivers of bicycle commuting intention should receive more attention because they explain a large part of the intention to commute by bicycle. This is especially valid when the variables are split up into sub-items.

This finding led to input for the following steps in the needsfinding phase. The interviews with stakeholders were more focused on psychographic elements than would have been the case without the findings of this study. Also, the focus sessions with experts addressed the behavioural side of cycling. Without these results, the behavioural side would not have been discussed. In this way, it helped the researchers to avoid the themes for which the effect on behaviour were not significant but provided living lab actors with proven themes for brainstorming in the needsfinding phase.

Moreover, by mapping the needs of the end users, a better plan can be made for the later phases in the living lab. The researchers now know that prototypes of innovations have to include behavioural components. For example, knowing that the family plays an important role in the bicycle commuting intention, researchers can ensure that they involve families in the research. These findings give the opportunity to test this effect in a later phase (after the needsfinding phase). For example, by including families of employees in an experiment, the lab can assess how the family can stimulate a family member to commute to work by bicycle.

Another measurement in the test phase may consist of promotion campaigns that are focused on direct benefit, as this seemed to have a significant influence on bicycle commuting intention. Often in the Netherlands, promotion campaigns about cycling are focused on safety. However, this research shows that the items of direct benefit have to be emphasized in order to stimulate bicycle commuting intention. These items concern: the comfortability of the route, the pleasure derived from riding a route, and how easy it can be to fit cycling into most lifestyles. Given that these elements have a significant influence on bicycle commuting intention for potential cyclists, communication geared towards these elements would lead to a higher bicycle commuting intention. However, in the Netherlands, home and work are not fully integrated. Therefore, results from country to country may differ and promotion campaigns should be designed accordingly. For this living lab in the Netherlands, emphasis will be placed on providing more direct benefit in campaigns.

Furthermore, this research has also clarified what type of people (users) should be selected for the subsequent phase in the living lab. On the one hand, the control variable past behaviour had a direct effect on bicycle commuting intention and can therefore be seen as an additional independent variable. It is therefore important for employers to give their employees a good experience when they cycle to work for the first time, because the intention to cycle more often is directly dependent on (positive) past behaviour. On the other hand, the variable with the largest effect on bicycle commuting intention is perceived behavioural control. This variable had an interaction effect with working distance. The influence of working distance decreases if employees are provided with more control in cycling to work.

Both findings can be tested in a new phase of the living lab. One way to test this is by introducing employees to an electric bicycle and test whether their perceived behavioural control changes over time. Also, introducing the electric bicycle to (new) employees would make commuting easier (past behaviour). Alternatively, by using an electric bicycle, the time of arrival at work becomes more predictable as compared to public transport, which also contributes to perceived behavioural control.

All in all, this research provides insights in how to tackle the next phases in the living lab. The findings give guidance in an unstructured process of user requirements and needs. Accordingly, topics are being discussed in conversations with users that would not have been discussed without these findings. The findings show that changes should be made in the regular approach of cycle programs offered by governmental institutions and employers to encourage employees to cycle to work. Not only contextual factors are making a difference in the intention to cycle to work. In fact, this research shows that personal factors are particularly important. For this reason, organizations should reevaluate their strong focus on contextual interventions and put more focus on personal factors in their bicycle policy programs and living labs. Future researchers should keep an eye on the process of a living lab, and provide a structure to measure the stakeholders' findings, for example by dividing the living lab into phases.

About the Authors

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Appendix 1. Multiple regression analyses

A. Main analyses

Step 1: Control Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gender	-0.006	-0.023	-0.024	-0.005	-0.015	-0.008	-0.004	-0.025
Age	-0.009	-0.036	-0.034	-0.002	-0.034	-0.008	-0.008	-0.037
Working distance	-0.136***	-0.014	-0.117***	-0.094***	-0.018	-0.135***	-0.135***	-0.012
Household structure 1†	-0.040	-0.016	-0.030	-0.030	-0.025	-0.040	-0.041	-0.017
Household structure 2†	0.019	0.035	0.019	0.037	0.027	0.020	0.018	0.032
Household structure 4†	-0.006	-0.001	-0.011	-0.017	0.012	-0.002	-0.006	0.001
Household structure 5†	-0.008	0.003	-0.009	-0.005	0.005	-0.008	-0.007	0.004
Household structure 6†	-0.015	-0.016	-0.017	-0.009	-0.020	-0.015	-0.014	-0.015
Household structure 7†	0.025	0.033	0.019	0.034	0.033	0.026	0.024	0.031
Working hours	-0.030	-0.017	-0.001	-0.030	-0.034	-0.030	-0.030	-0.016
Timeblock1 (06.00u-12.00u)	-0.041	-0.035	-0.035	-0.039	-0.039	-0.039	-0.044	-0.037
Timeblock2 (12.00u-18.00u)	0.064	0.038	0.046	0.032	0.065*	0.062	0.061	0.038
Timeblock3 (18.00u-24.00u)	0.005	0.029	0.021	0.015	0.018	0.007	0.006	0.030
Timeblock4 (00.00u-06.00u)	-0.047	-0.011	-0.039	-0.037	-0.015	-0.047	-0.045	-0.010
Timeblock5 (no usual time)	0.022	0.013	0.019	0.016	0.016	0.024	0.019	0.015
Luggage	-0.006	0.010	-0.002	-0.008	0.015	-0.004	-0.006	0.010
Frequency of past behaviour	0.750***	0.355***	0.566***	0.631***	0.452***	0.750***	0.743***	0.352***
Physical condition	0.053*	0.005	0.007	0.044*	0.031	0.053*	0.055*	0.006
Car ownership	0.005	0.037	0.041	0.008	0.019	0.006	0.006	0.041
Organization 2‡	0.047	0.036	0.043	0.047*	0.035	0.039	0.058*	0.035
Organization 3‡	0.037	-0.009	0.005	0.036	0.000	0.022	0.053	-0.022

Step 2: Main Effects	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Attitude: direct benefit		0.179***	0.298***					0.179***
Attitude: awareness		0.005	0.015					0.004
Subjective norms: colleagues		0.052		0.056				0.051
Subjective norms: family		0.116**		0.231***				0.111**
Subjective norms: friends		-0.049		-0.054				-0.046
Subjective norm importance		0.012		0.015				0.011
Perceived behavioural control		0.355***			0.470***			0.360***
Facilities bike						-0.025		-0.033
Facilities other						0.021		-0.005
Financial incentives bike							0.044	0.021
R2	0.713	0.807	0.756	0.748	0.780	0.714	0.715	0.808
Adj. R2	0.703	0.797	0.746	0.737	0.772	0.703	0.704	0.797
F change	70.774***	38.401***	49.203***	19.917***	175.785***	0.683	3.24	27.199***
F	70.774***	83.025***	76.303***	69.177***	93.516***	64.611***	67.958***	75.108***
part correlation			0.179	0.134	0.258			

N= between 595 and 647
*p<0.05; **p<0.01 ; ***p<0.001
†Household structure 3 is the reference category
‡ Organization 1 is the reference category

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Appendix 1. Multiple regression analyses (continued)

B. Additional analyses

Step 1: Control Variables	9	10	11
Gender	-0.029	-0.004	-0.016
Age	-0.043	-0.007	-0.035
Working distance	-0.148***	-0.095**	0.003
Household structure 1†	-0.019	-0.031	-0.026
Household structure 2†	0.016	0.032	0.025
Household structure 4†	-0.017	-0.020	0.000
Household structure 5†	-0.009	-0.005	-0.007
Household structure 6†	-0.014	-0.011	-0.025
Household structure 7†	0.017	0.035	0.036
Working hours	-0.005	-0.034	-0.038*
Timeblock1 (06.00u-12.00u)	-0.023	-0.037	-0.015
Timeblock2 (12.00u-18.00u)	0.044	0.032	0.043
Timeblock3 (18.00u-24.00u)	0.017	0.011	0.009
Timeblock4 (00.00u-06.00u)	-0.038	-0.033	-0.027
Timeblock5 (no usual time)	0.014	0.016	0.019
Luggage	0.003	-0.009	0.009
Frequency of past behaviour	0.533***	0.632***	0.386***
Physical condition	-0.008	0.044*	0.036
Car ownership	0.029	0.006	0.033
Organization 2‡	0.039	0.051*	0.031
Organization 3‡	-0.012	0.039	-0.001

Step 2: Main Effects	9	10	11
Attitude lifestyle	0.136***		
Attitude time saving	0.042		
Attitude comfortable	0.082*		
Attitude pleasantness	0.139***		
Subj.n. colleague: expect		0.053	
Subj.n. colleague: encourage		-0.006	
Subj.n. colleague: appreciate		0.028	
Subj.n. family: expect		0.129**	
Subj.n. family: encourage		0.061	
Subj.n. family: appreciate		0.082*	
Subj.n. friends: expect		-0.125**	
Subj.n. friends: encourage		0.058	
Subj.n. friends: appreciate		0.002	
PBC opportunity			0.124***
PBC trust			0.472***
PBC reversed hampered			0.009
R2	0.771	0.752	0.819
Adj. R2	0.761	0.739	0.812
F change	36.421***	9.967***	113.749***
F	78.491***	58.565***	110.196***

N= between 595 and 647
*p<0.05; **p<0.01 ; ***p<0.001
†Household structure 3 is the reference category
‡ Organization 1 is the reference category

Citation: Savelkoul, L., & Peutz, M. 2016. Needsfinding in Living Labs: A Structured Research Approach. *Technology Innovation Management Review*, 7(2) 42–51. http://timreview.ca/article/1057

Keywords: living lab, needsfinding, cycling, commuting, intention, theory of planned behaviour

Author Guidelines

These guidelines should assist in the process of translating your expertise into a focused article that adds to the knowledge resources available through the *Technology Innovation Management Review*. Prior to writing an article, we recommend that you contact the Editor to discuss your article topic, the author guidelines, upcoming editorial themes, and the submission process: timreview.ca/contact

Topic

Start by asking yourself:

- Does my research or experience provide any new insights or perspectives?
- Do I often find myself having to explain this topic when I meet people as they are unaware of its relevance?
- Do I believe that I could have saved myself time, money, and frustration if someone had explained to me the issues surrounding this topic?
- Am I constantly correcting misconceptions regarding this topic?
- Am I considered to be an expert in this field? For example, do I present my research or experience at conferences?

If your answer is "yes" to any of these questions, your topic is likely of interest to readers of the TIM Review.

When writing your article, keep the following points in mind:

- Emphasize the practical application of your insights or research.
- Thoroughly examine the topic; don't leave the reader wishing for more.
- Know your central theme and stick to it.
- Demonstrate your depth of understanding for the topic, and that you have considered its benefits, possible outcomes, and applicability.
- Write in a formal, analytical style. Third-person voice is recommended; first-person voice may also be acceptable depending on the perspective of your article.

Format

1. Use an article template: .doc .odt
2. Indicate if your submission has been previously published elsewhere. This is to ensure that we don't infringe upon another publisher's copyright policy.
3. Do not send articles shorter than 1500 words or longer than 3000 words.
4. Begin with a thought-provoking quotation that matches the spirit of the article. Research the source of your quotation in order to provide proper attribution.
5. Include a 2-3 paragraph abstract that provides the key messages you will be presenting in the article.
6. Provide a 2-3 paragraph conclusion that summarizes the article's main points and leaves the reader with the most important messages.
7. Include a 75-150 word biography.
8. List the references at the end of the article.
9. If there are any texts that would be of particular interest to readers, include their full title and URL in a "Recommended Reading" section.
10. Include 5 keywords for the article's metadata to assist search engines in finding your article.
11. Include any figures at the appropriate locations in the article, but also send separate graphic files at maximum resolution available for each figure.

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