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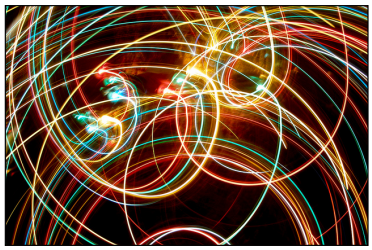

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Living Labs

Welcome to the March 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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Contribute to the TIM Review in the following ways:

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About TIM

The TIM Review has international contributors and readers, and it is published in association with the Technology Innovation Management program (TIM; timprogram.ca), an international graduate program at Carleton University in Ottawa, Canada.

Editorial: Living Labs

Chris McPhee, Editor-in-Chief
Anna Ståhlbröst, Abdolrasoul Habibipour,
Mari Runardotter, and Diana Chronéer, Guest Editors

From the Editor-in-Chief

Welcome to the March 2019 issue of the *Technology Innovation Management Review*. This month's editorial theme is Living Labs, and it is my pleasure to introduce our guest editors: **Anna Ståhlbröst**, **Abdolrasoul Habibipour**, **Mari Runardotter**, and **Diana Chronéer** from Luleå University of Technology and Botnia Living Lab in Sweden.

For this special issue, most of the articles were selected and revised from papers presented at OpenLivingLab Days 2018, which was held in Geneva, Switzerland, from August 22–24. The theme for the conference was "Sustainability and the 2030 Agenda for Sustainable Development".

The next OpenLivingLab Days will be held in Thessaloniki, Greece, from September 3–5, 2019, and we would like to take this opportunity to invite you to participate. The theme will be "Co-creating Innovation: Scaling up from Local to Global". We hope you will take advantage of the various opportunities to participate in workshops and research discussions and to interact with a great diversity of living lab practitioners and innovators from all over the world. The conference is co-organized by the European Network of Living Labs (EnoLL; enoll.org), Thess-AHALL, and the Aristotle University of Thessaloniki. For details, please see the OpenLivingLab Days website (openlivinglabdays.com).

For future issues, we are accepting general 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, and proposals for future special issues.

Finally, we invite you to attend ISPIM Connects Ottawa (ispim-connects-ottawa.com), which will be held in Ottawa, Canada, from April 7–10, 2019. ISPIM Connects Ottawa is a three-day event that will bring together world-renowned innovation managers, researchers, and business and thought leaders to share insights on specific local and global innovation challenges as well as general innovation management hot-topics. The TIM Review and its associated academic program at Carleton University, the TIM Program (timprogram.ca), are proud to be the local hosts of the event in collaboration with other partners.

Chris McPhee
Editor-in-Chief

From the Guest Editors

We are excited and happy to present this special issue on the theme of Living Labs, because it relates to many important trends that affect society, its citizens, and its stakeholders. These trends are, for instance, climate change, urbanization, individualization, digitalization, and automation – all of which will transform society as we know it. Hence, there is a diversity of immediate challenges that need to be managed directly, but a long-term perspective is also required is to co-create a better society for all.

In living labs, one fundamental objective is to support the development of a better society by means of multi-stakeholder engagement in open innovation and experimentation processes carried out in real-world contexts. This means that living labs not only support innovation processes but also the advancement of society, an advancement that should be sustainable, and they add value for citizens and the labs' other stakeholders. To reach this goal, a responsible, co-creative, and human-centred approach is preferred. In living labs, a plethora of accompanying methods, tools, and practices are applied by experts and practitioners, but to reach a sustainable and better society, both the innovation processes and the innovations being developed must contribute to the same goal.

Due to their focus on innovation, engagement, and real-world context, living labs give us great potential to co-create a desired future. In this special issue, the authors contribute with different perspectives and insights related to living labs and their objectives of societal

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advancement and sustainablity by reflecting on an emerging type of living labs, methods and approaches that facilitate living labs, and the value of the living lab approach.

First, **Lotta Haukipuro**, **Satu Väinämö**, **Leena Arhippainen**, and **Timo Ojala** from the University of Oulo in Finland seek to understand the impact of the living lab approach in an eHealth accelerator. They report on the added value the living lab offers to participating companies and its impact on the development, growth, and market success of the companies. The result of their study is the identification of a new accelerator model in which the living lab approach is included.

In the second article, **Justus von Geibler**, **Julius Piwowar**, and **Annika Greven** from the Wuppertal Institute in Germany aim to increase the usability of the United Nations' 2015 Sustainable Development Goals by proposing a four-stage approach for structuring the innovation process. They have developed an online tool, the SDG-Check, to support living lab innovators in assessing sustainability from the early stages of product and service development. The results from using this tool has shown that it can support and inspire dialogue when considering sustainability at the "fuzzy front end" of innovation.

Next, **Tiziana C. Callari**, **Louise Moody**, **Janet Saunders**, **Gill Ward**, **Nikki Holliday**, and **Julie Woodley** from Coventry University in England address the need for guidelines to steer and support the design and maintenance of living lab initiatives and to support relationships and engagement with stakeholders and users. Drawing on their interviews with older adults and their family members collaborating to establish a living lab environment, this study illustrates that openness is a vital aspect in living lab initiatives, because it helps create engagement and commitment among the involved stakeholders.

Then, **Diana Chronéer**, **Anna Ståhlbröst**, and **Abdolrasoul Habibipour** from Luleå University of Technology in Sweden sought to unravel the confusion and complexity of the urban living lab concept since it is interpreted and described in diverse ways by analyzing its key components and how it differs from traditional living labs. The result of this article is an expanded model that identifies the seven key components of an urban living lab and descriptions of how they are shaped in the urban context.

The final article, by **Dimitri Schuurman**, **Aron-Levi Herregodts**, **Annabel Georges**, and **Olivier Rits** from imec.livinglabs in Belgium, introduces Innovatrix – an innovation management framework for living lab projects. In addition to describing the framework and the value it provides to practitioners seeking to develop business models and guide living lab activities, the authors provide three illustrative case studies from their overall sample of 40 living lab innovation projects that were used to iteratively develop this practical tool.

We hope that you will enjoy reading the diversity of articles in this special issue. Each one contributes to deepening our understanding of how to apply, support, and understand the living lab approach to create a better society.

Anna Ståhlbröst, Abdolrasoul Habibipour,
Mari Runardotter, and Diana Chronéer
Guest Editors

Editorial: Living Labs

Chris McPhee, Anna Ståhlbröst, Abdolrasoul Habibipour, Mari Runardotter, and Diana Chronéer

About the Editors

Chris McPhee is Editor-in-Chief of the *Technology Innovation Management Review*. Chris 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. He has 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.

Anna Ståhlbröst is the Chair Professor in Information Systems at Luleå University of Technology, Sweden. Her research interests focus on the possibilities and challenges with the ongoing digital transformation for people, organizations, and society. In particular, she is interested in the citizen perspective when digital service innovations are developed within the context of urban living labs for smart cities and regions. Her research is related to different application areas such as smart cities and regions, crowdsourcing, everyday use, and online privacy. Her research has been published in several international journals, conference proceedings, and books.

Abdolrasoul Habibipour is a PhD student in Information Systems at Luleå University of Technology in Sweden and is a User Engagement Expert at Botnia Living Lab, Sweden. His research focuses on user engagement in living lab context, with a particular emphasis on users' motivations and needs. Abdolrasoul has experience teaching and supervising students at the undergraduate and postgraduate level and also serves as a reviewer in various international conferences and scientific journals. He has been involved in international innovation and research projects such as Privacy Flag and USEMP projects and is currently working in UNaLab and U4IoT projects, all of which are financed by the European Commission.

Mari Runardotter is a PhD in Social Informatics from the Luleå University of Technology. Since 2009 she has been working as Senior Lecturer, at the division Computer Science, at Luleå University of Technology. Her research focuses on social, societal and organizational effects of IT, primarily in the area of e-government and e-governance. She is also interested in issues related to availability and accessibility of cultural heritage materials. In her research Runardotter uses theories and methods that emphasize social, societal, cultural, organizational and gender aspects in the interaction between humans and information systems.

Diana Chronéer is an Associate Professor in the Information Systems department at Luleå University of Technology in Sweden. She teaches organizational development through IT and sustainable business models from a digital perspective. Her main research interests are in the areas of digital service innovation, business model development, information logistics, and project management.

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Keywords: living labs, sustainability, innovation, open innovation, UN Sustainable Development Goals, accelerators, urban living labs, stakeholders, tools, frameworks, business models

Applying a Living Lab Approach Within an eHealth Accelerator

Lotta Haukipuro, Satu Väinämö, Leena Arhippainen, and Timo Ojala

> *"The living lab forces each company to make a product market ready."*
>
> A company representative from the eHealth accelerator

Through this study, we seek to understand the impact of the use of the living lab approach on product and business development in an eHealth accelerator. In the case accelerator, 20 startups developed innovative products atop the European FIWARE Future Internet technology platform. The novel design element of the case accelerator was the use of the living lab approach that was included for the purpose of engaging end users in the development and testing of new product prototypes. Our main result is that the living lab approach provided added value to participating companies and resulted in changes in their product development and marketing strategies. Overall, the case accelerator and the use of the living lab approach had a significant impact on the development, growth, and market success of the companies. Based on the results of the case accelerator, we propose the generic accelerator model presented by Pauwels and co-authors in 2016 to be extended with a new design element, the living lab approach.

Introduction

This article contributes to the research of new business development within accelerator programs using the living lab approach in the particular field of eHealth. Although the accelerator phenomenon originating from the United States is rather new, it has been recognized nationally and internationally as a key contributor to the success of business startups (Dempwolf et al., 2014). Due to its relatively short history, research on the impact of accelerators on new businesses is scarce, and systematic information is thin and fragmented (Cohen & Hochberg, 2014; Hallen et al., 2016; Hathaway, 2016; Hoffman & Radojevich-Kelley, 2012). Pauwels and co-authors (2016) have conducted pioneering accelerator research, synthesizing a generic accelerator model from 13 case accelerators. However, research regarding a novel element, the living lab approach, within an accelerator is missing. Hence, this article offers new knowledge and a different viewpoint to this topic, further developing the generic accelerator model.

Our case accelerator is the European multi-phase accelerator FICHe (Future Internet CHallenge eHealth). FICHe was one of the 16 accelerators in the FIWARE Accelerator Programme that was a part of the 6-year €450 million Future Internet Public-Private Partnership Programme (FI-PPP) launched by the European Commission in 2011. The aim of the FI-PPP programme was to speed up the development and adoption of Future Internet technologies in Europe. This included the development of Future Internet technology platform called FIWARE. The FIWARE Accelerator Programme then challenged European small and medium-sized enterprises (SMEs) and startups to develop innovative applications and businesses on selected industry sectors using the FIWARE technology (EC, 2018; FIWARE, 2016).

The purpose of this study is to understand the impact of the living lab approach on product and business development in FICHe. We focus especially on the third and final phase of FICHe, which used the living lab approach to engage end users in product and business development through field trials conducted according to the living lab approach. In FICHe, the living lab approach referred to multi-stakeholder participation, in particular end-user involvement in the development of

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eHealth solutions from idea to market-ready prototype that were tested in an authentic use environment with end users. In FICHe, the term "end user" referred to the members of the intended target group of a particular eHealth solution, such as patients, consumers, doctors, nurses, and clinicians. The term "customer" referred to the target organization to which a particular eHealth solution was planned to be sold, such as hospitals and clinics. The research data have been collected from the 20 companies (finalists) that were selected for the final phase of the accelerator, out of the 80 companies selected for the first phase through an open call. At the end, the 20 companies delivered market-ready eHealth solution tested with end users in living labs.

The article is organized as follows. First, we overview related work in the research literature. Then, we present the research design, the case accelerator, and the method used to collect and analyze the research data. Then, we report our empirical findings on the living lab approach, propose a new accelerator model extended with the living lab element, and discuss the case accelerator's impact on business development. Finally, we conclude the article with our responses to the research questions, and we provide final remarks.

Related Research

Accelerators

Accelerators have become a common component of regional growth infrastructure, playing a key role in scaling up growth-oriented startups (Hathaway, 2016). After the "Internet bubble" burst in 2000, the burden and risk of investing in nascent firms was left to angel investors, as venture capitalists (VC) were reluctant to fund them anymore. Due to this, many new ventures had difficulties in raising funding to launch their business. This led to the birth of new investment firms known as accelerators (Hoffman & Radojevich-Kelley, 2012). The first accelerator, Y Combinator, was founded in 2005 in the USA, followed by Techstars in 2007. Also in 2007, the first European accelerator, SeedCamp, was set up in the United Kingdom.

Accelerators aim to help startups to further develop their initial business idea, identify customer segments, and build the team during the formation stage of the venture. Building on research by Zott and Amit (2010) and studying 13 different accelerators, Pauwels and co-authors (2016) proposed a generic accelerator model that comprises five design elements and three design themes. The five *design elements,* as described below, are they key building blocks of the accelerator model:

1. Program package: the services offered to startups
2. Strategic focus: a choice regarding industry, sector, or geographical focus
3. Selection process: how the SMEs are selected by the accelerator
4. Funding structure: investor, corporate, public, or alternative resources
5. Alumni relations: the accelerator's relationships with its alumni

The *design themes* reflect *three ways* of orchestrating and connecting the design elements (Zott & Amit, 2010) within a particular accelerator:

1. Ecosystem builder: develops an ecosystem of customers and stakeholders around the accelerated company
2. Deal-flow maker: identifies promising investment opportunities for business angels, venture capitalists, or corporates
3. Welfare stimulator: promotes startup activity and boosts economic growth, within either a specific region or a technological domain. The welfare accelerator's stakeholders usually include government agencies.

Moreover, accelerators characteristically set up programs of limited duration that select startups in batches through open calls and end with a demo day where startups introduce and pitch their solutions to investors. Accelerators typically provide seed funding, training, mentorship, and networking opportunities with peer startups, mentors, and investors (Cohen & Hochberg, 2014; Dempwolf et al., 2014; Hathaway, 2016; Hoffman & Radojevich-Kelley, 2012). The most commonly mentioned benefits of accelerators are networking opportunities and mentorship (Cohen, 2013; Hoffman & Radojevich-Kelley, 2012).

In recent years, the number of new accelerators has been growing rapidly, and they have increasingly focused towards specific industries such as health. The first health accelerator, Rock Health, emerged in 2011 (Apodaca, 2013; Cohen & Hochberg, 2014). By 2017, over 7,000 startups have been accelerated in over 600 programs and they have collectively raised over $29,000 million USD of funding (Christiansen, 2017). However,

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according to a report by the California Health Care Foundation (Apodaca, 2013), the fast and iterative accelerator approach that has been successful in the Internet sector, is not necessarily a proper model for the complex and entrenched healthcare field. The report suggests that healthcare startups would benefit from services such as direct interaction with customers to gain understanding of the real operating environments, testing of products with experienced clinicians and medical staff, and tailored programs given that health technology startups have wide range of needs depending on their stage of development (Apodaca, 2013). Hence, the living lab approach, which builds on end-user involvement, was identified as potentially appropriate for an eHealth accelerator.

Living labs and new product development

The living lab approach has emerged from user innovation (von Hippel, 1976, 2009), open innovation (Chesbrough, 2003), and related paradigms, the most recent trend being the shift to open innovation 2.0 (OI2), which emphasizes experimentation and prototyping in quadruple-helix settings, enabling easy and fast access to co-creation spaces geographically or thematically (European Commission, 2016). The living lab can be seen as a methodology that emphasizes end-user involvement and multi-stakeholder participation in the development of services and products. The approach is positioned in between user-centered design and participatory design (Dell'Era & Landoni, 2014). This research era is rather new, and still no coherent, widely recognized definition exists (Dell'Era & Landoni, 2014; Leminen et al., 2012; Westerlund et al., 2018). Schuurman (2015) views the living lab as a specific approach that offers a structured approach to open innovation and that has been used specifically by startups and SMEs. The five key elements that are essential in a living lab are: active user involvement (empowering end users to thoroughly impact the innovation process), a real-life setting (testing and experimenting), multi-stakeholder participation (involvement of end users and other stakeholders), a multi-method approach (different methods and tools), and co-creation (iterations of design cycles with different sets of stakeholders) (ENoLL, 2019; Robles et al., 2015).

Living labs are driven by two main factors: involving users in the early stages of the innovation process and experimentation in real-world settings that aim to provide structure to user participation (Almirall & Wareham, 2008). Therefore, living lab projects are a specific case of open innovation where companies open up their innovation processes to users or customers (Schuurman et al., 2013), which can be linked to the user innovation paradigm originally presented by von Hippel (1976). The living lab approach has been seen as particularly beneficial in the development of new products or services as the design process allows users to interact with the new products and services in their daily lives (Bergvall-Kåreborn & Ståhlbröst, 2009; Dell'Era & Landoni, 2014). Thus, end-user feedback and experience through, for example, user testing, can bring up novel insights and issues that the product or service developer has not necessarily been aware of (Anttiroiko, 2016; Haukipuro et al., 2014, 2016; Ståhlbröst, 2013). The earlier the users are involved, the more beneficial it may prove to be; for example, development costs can be saved when living lab testing is conducted in the early phase of the development, when adjustments and corrections based on user feedback are still possible to make cost-efficiently.

Research Design

The case study research approach aims to create understanding of the dynamics of a contemporary phenomenon in context. It is suitable for description and deduction, in particular when seeking answers to "how" and "why" questions (Yin, 1994). One advantage of the case study approach is that it helps to create deeper understanding of specific instances of a phenomenon (Santos & Eisenhardt, 2004). In this study, a multiple case study approach was applied, so that each of the 20 companies is regarded as an individual case. Multiple case research begins with data and ends with theory, includes a priori defined research questions, clearly designated populations to be investigated and from which to draw observations as well as to construct definition and measure them with triangulation. The ultimate aim of the multiple case study is to develop theory by dismantling and re-assembling the research objects at a higher level of abstraction (Santos & Eisenhardt, 2004). One benefit of the multiple case study is that it enables data analysis within each case and across different situations. The multiple case study aims to understand the similarities and differences between the cases and therefore identify important influences (Gustafsson, 2017). In this study, the findings are based on multiple data sources such as interviews, surveys, and documents gathered from the 20 companies participating in the FICHe accelerator. Due to the time period and multiple phases of the accelerator, the data comprised a large entity that was systematically

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analyzed and organized in accordance with selected research themes and questions. The interpretation of the data, triangulation, and connections were compiled, and the conclusions were drawn from the basis of key findings.

Case accelerator: FICHe

The objective of the FIWARE Accelerator Programme was to boost the adaptation of FIWARE technologies among application developers encouraging entrepreneurs, SMEs and startups to develop innovative solutions based on the FIWARE technology (FIWARE, 2016). The Accelerator Programme comprised 16 different accelerators focused on eight industrial sectors. FICHe was the only accelerator focusing on eHealth with €6.24 million of total funding. While most accelerators had multiple programs, a few, including FICHe, had only one program comprising a three-phase funnel model where, after each phase, half of the companies were selected to continue to the next phase. All accelerators offered funding, coaching and mentorship, business and FIWARE training, as well as networking opportunities. FICHe differed from other accelerators in that, at the end of the accelerator process, there was a living lab phase that involved testing and validation of prototypes with end users. This was due to two key reasons. In FICHe, the health sector influenced the selection of the living lab approach as, for example, the Spanish consortium partners considered that validating the solutions in a real environment such as hospitals with professionals and end users (patients) was crucial for the development of successful eHealth solutions. Furthermore, one of the aims of FI-PPP was user involvement due to which, for example, the European Network of Living Labs (ENoLL) promoted living labs to be included in FIWARE accelerator programme (Ballon, 2013; Rucic & Kivilehto, 2011).

Figure 1 depicts the phasing and services of FICHe. The initial selection of companies was conducted through an open call that received 308 applications from over 30 countries in Europe. An independent review committee selected the 80 highest-potential proposals complying with the requirements of the open call. The two main selection criteria were the market opportunity of the proposed eHealth solution and the quality of the team. After the first and the second phases, the review committee selected the companies that would advance to the next phase. FICHe ended with a demo day where the companies introduced their solutions to investors and key stakeholders. Thus, the overall outcome were 20 market-ready prototypes of new and innovative eHealth solutions built atop the FIWARE technology. The main objectives of the three phases of the accelerator (Figure 1) were as follows:

- Phase 1 (80 companies): support SMEs and startups in maturing their idea into a business model, €15,000 funding
- Phase 2 (40 companies): support SMEs and startups in building proof of concepts (PoCs) based on the FIWARE technology, €50,000 funding

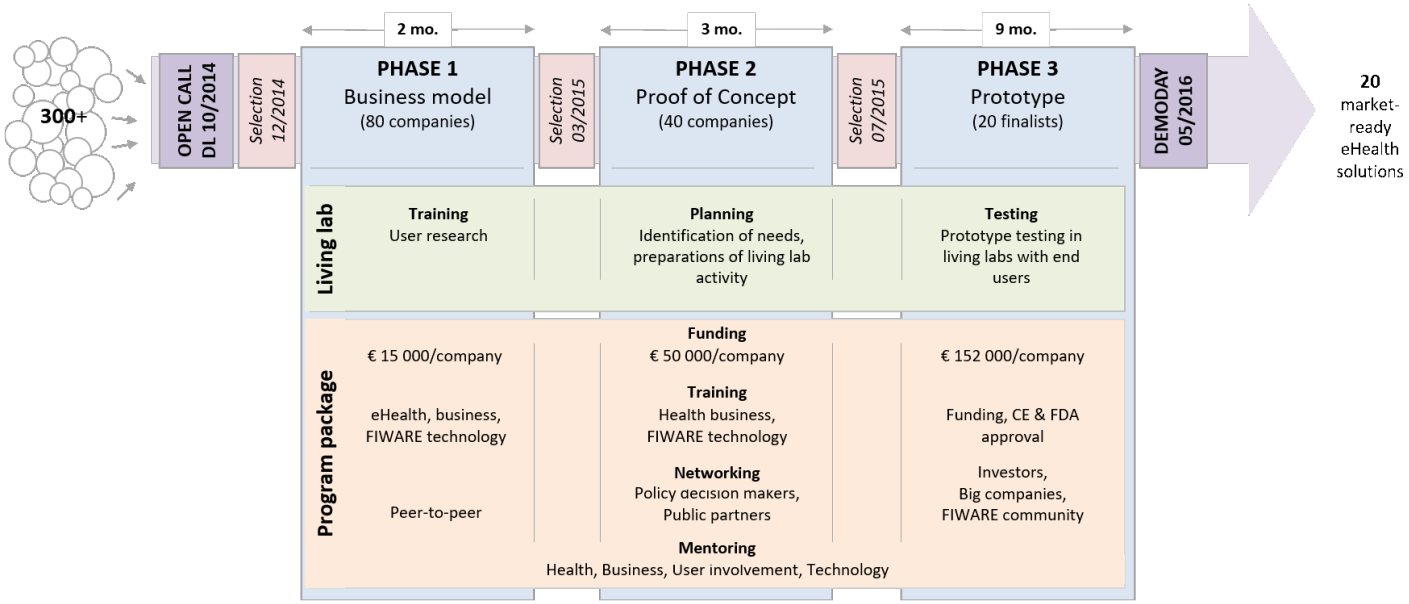

Figure 1. The phasing and services of the FICHe accelerator.

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- Phase 3 (20 companies, "finalists"): support SMEs and startups in turning their PoC into a working prototype, create go-to-market strategy, and test the prototype in living labs, €152,000 funding.

The services provided by FICHe included living lab services, business and technology training, networking, and mentoring. The overall goal of the living lab was to enable testing of eHealth prototypes in real environments with end users in Phase 3. In the first two phases, companies were encouraged to utilize three different living labs of distinct focus areas – business to business, healthcare, and consumer markets – to engage end users in the development of the companies' solutions. Bootcamps were organised to train companies on maturing eHealth solution ideas into business models, and on the living lab concept. Training on user research focused on user involvement methods, setting up a well-organized living lab, and engaging end users in testing. For example, the bootcamp organized in Oulu, Finland, included a workshop where company representatives engaged in feedback discussions with different types of end users (n=11) regarding their eHealth solution ideas. A living lab platform and end-user involvement tool called PATIO (patiolla.fi) (Anttiroiko, 2016; Haukipuro et al., 2014, 2016), was used to invite consumers to the workshop. PATIO was made available to other bootcamps and FICHe companies, as well, and it was used for collecting end-user feedback on PoCs through online surveys. In Phase 2, the companies' needs for support regarding the implementation of living labs were identified, and companies prepared plans for the upcoming living lab activity to be conducted in Phase 3. With the guidance of the FICHe mentors, the 20 finalists documented the execution and results of living lab activities.

Data collection and analysis

Table 1 describes the primary and secondary research data used in this study. Our primary research data consist of in-depth interviews of company representatives, several questionnaires conducted in different phases during and after FICHe, and a variety of documents provided by companies. In-depth interviews are optimal for documenting individuals' personal histories, perspectives, and experiences, particularly when sensitive topics are being explored (Mack et al., 2005). Secondary data comprises project documents, project reports, and surveys used as supporting material. Based on the data, we seek to address the following two research questions:

RQ1: What was the experienced impact of the FICHe accelerator on the development of new businesses by the participating companies?

RQ2: How did the participant companies experience the impact of the living lab, in particular end-user involvement, during the FICHe accelerator (i) on the development of their eHealth solutions, and (ii) on market access?

The collected data were evaluated and analyzed for patterns and linkages. Following the principles of the multiple case analysis method, cases were treated as separate instances of the focal phenomenon, which allows replication, aiming to create as close a match between data and theory as possible (Santos & Eisenhardt, 2004). The data analysis was continued following a deductive approach so that concepts were searched from the data under the pre-defined themes. The concepts were then grouped to categories and named.

The key data of the 20 finalist companies are presented in Appendix 1. They were mostly (80%) startups with a relatively small team of application developers or service providers. Among the solutions, 60% were based on a completely new (disruptive) approach whereas 40% were improvements to an existing solution (incremental). The main target market (90%) was business to business (B2B) and, in the beginning of the FICHe, 70% of the companies aimed at a global market.

Findings

Companies' expectations and needs regarding the use of living labs were collected with the "living labs planning survey". Additionally, the interviews of the company representatives during an eHealth event were conducted as one-on-one discussions. At the beginning of Phase 3, companies submitted their plans for the upcoming living lab activity.

Our analysis shows that the finalists did not have a clear plan or knowledge about user involvement methods at the mid-stage of the accelerator. For instance, they were not aware of available living labs or methods to involve end users in testing. Almost all finalists needed guidance to set up a living lab and conduct user studies. Similar findings were obtained from the one-on-one discussions with company representatives. Planning documents provided by the companies in Phase 3 varied a lot in terms of the maturity of their intended

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Table 1. Description of research data

Primary Research Data	When	n	Type	Used to Assess
Living lab planning survey	Phase 2	20	Questionnaire	Living lab impact
Living lab planning one-on-one discussion	Phase 2	20	Interviews with key company personnel	Living lab impact
Phase 3 plan	Phase 3	20	Document provided by company	Business & living lab impact
Living lab reports	Phase 3	20	Report provided by company	Living lab impact
Go-to-market strategy	Phase 3	20	Document provided by company	Business impact
Business model	Phase 3	20	Document provided by company	Business impact
FICHe impact survey	After Phase 3	20	Questionnaire	Business & living lab impact
Follow-up survey	1 year after FICHe	9	Questionnaire	Current business & living lab status of finalists
Secondary Research Data	**When**	**n**	**Type**	**Used to Assess**
FICHe application forms	Phase 1	20	Open call application of company	Basic information of companies
FI-IMPACT business survey	Phase 1	20	Questionnaire	Basic information of companies
FICHe project reports	Phases 1–3	10	Reports provided by FICHe project	Business & living lab impact
Desk follow-up study	1 year after FICHe	11	Questionnaire	Current status of finalists

use of living labs. To summarize, most finalists were not familiar with the living lab approach and thus needed strong support, guidance, and training from FICHe in planning and implementing the testing of their prototypes in a living lab.

Implementation of living labs

The living lab reports of the finalists documented the implementation and outcome of their living lab testing. The reports showed that companies conducted several tests (1–6) in their living labs. All finalists were offered an opportunity to use some of the three living labs provided by FICHe in the Netherlands, Spain, and Finland. However, based on the reports, most companies used local living labs residing in public or private clinics or hospitals, for example. The duration of living lab testing varied from few weeks up to nine months. In addition, the methodology used in the living labs differed mainly due to the varying nature of the companies' prototypes. Therefore, the living lab testing of some technical hospital solutions was reminiscent of clinical testing. End users were involved in all living labs; observations, interviews of users and professionals, focus group discussions, and surveys were among the most common user involvement methods.

As an example of a living lab implementation, company 58 reported their living lab activities as follows. First, they made a baseline measurement, which consisted of four observation periods in a care institution where their solution was used. Second, they organized two focus group discussions, one for patients and another for

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care personnel. Third, they conducted user tests of their prototype with ten users. Fourth, they conducted desk research with input from domain experts. Based on the feedback received from focus group discussions and user testing, the company modified their prototype, changed its design, adjusted the application, and refined their solution to meet the criteria of the care facility and markets.

After the last phase, the finalists completed the FICHe impact survey to provide feedback on various issues, including the benefits of the program, the living lab activity, impact on business, the value of the FIWARE technology, and overall progress during the accelerator. Sixteen of the 20 finalists confirmed that FICHe has contributed to the reinforcement of the company to successfully access international funding and markets. Funding, promotion and visibility, contacts (especially investors), opportunities to test in the living labs, and mentoring in refining the strategy, focus, or business model were among the most often-mentioned forms of FICHe contribution. However, two companies stated that FICHe had not made any contribution, and two companies expected FICHe's contribution to be possibly realized only after the end of the accelerator.

> *"Thanks to the living labs we could test and validate the technology and we could get international contacts."* (Company 79)

When asked how FICHe accelerator has contributed to the development, the finalists' responses varied considerably, but some consistencies were found. Mentoring and coaching were mentioned in many answers, as they had been helpful in creating business models. Funding and the living lab activities were also mentioned in several answers.

> *"At the end of the programme we have validated our business model and our product. We have our product working in an important hospital, having a good reference makes it easier to find customers, and we have more knowledge after the living lab."* (Company 29)

> *"[Because of the] focus on the living lab, we now have a product that is tested and new revenue stream models in different markets."* (Company 22)

Fourteen out of the 20 finalists reported that the involvement of end users had brought up untapped opportunities that had resulted in new business. For example, companies stated that they had obtained new development ideas from users, leading to new features in their solutions. New contacts, marketing of the solution, and greater visibility were also mentioned as positive effects of end-user involvement. Some companies also found a new market niche through the living lab activity:

> *"We have found processes in the hospital that we didn't think about before, where our product can be applied, which will bring us new opportunities in the near future."* (Company 29)

According to the findings, all 20 finalists reported that the impact of the living lab had been significant to the development of their eHealth solutions. In particular, the companies improved their solutions based on end-user feedback in form of adjustments, changes, and new features. The use of the living lab resulted in better solutions, thereby increasing the reliability and usability of the solutions. Additionally, living lab testing informed one company that the market for their solution was different than they had initially thought.

> *"It has helped us to detect problems on our solution and fix technical bugs. We have learned a lot about the public health sector and its technology."* (Company 5)

Based on the findings, nearly all companies planned to use living lab and involve end users in the future. All 20 finalists appreciated the overall value of end-user involvement as an essential part of current and future development. They clearly regarded the living lab activities conducted during FICHe as beneficial. Only one of the 20 finalists stated that they were not interested in living labs in the future, but still planned to include "end-user interviews" in their future operations.

> *"The living lab [user testing and refinement] is essential in any development process. We will be continuing to do this in the future."* (Company 53)

> *"…we plan to do more living lab trials before extending our platform for new scenarios. Living labs provide the opportunity to tune your product for the user."* (Company 65)

> *"The user feedback has been the most valuable asset in our living lab and has guided our product development iterations."* (Company 46)

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Overall, end user feedback was highly valued among the companies. One of the 20 finalists found that end-user involvement helped them to find the right business model and target group. The fixed scheduling of the living lab activity forced the companies to focus on relevant development actions to come up with a prototype that was mature enough for user testing.

> *"The living lab forces each company to make a product market ready."* (Company 14)

> *"FICHe has been 'a pressure cooker' in terms of developing our product and making it market ready."* (Company 58)

> *"In our case, providing us with a living lab environment to run a pilot has been the most appreciated benefit. This is the first requirement that an e-Health startup should accomplish in order to access international markets."* (Company 39)

Some finalists stated that the living lab phase should have been longer as, according to them, setting up and implementing the living lab was time-consuming. Overall, the companies felt that they received a lot of guidance, training, and help when it they were needed.

Follow-up survey

The 20 finalists were invited to complete a follow-up survey about a year after the conclusion of FICHe. The purpose of the survey was to report their status in terms of business activity, the number of employees and customers, current markets, and especially the living lab concept. The companies were asked whether they had continued the living lab activities started during FICHe, and, retrospectively, how they considered the impact of the living lab on their market access and product or service development. In total, nine responses were received to the follow-up survey, and all of these companies are still active in business. Five respondents employed less than ten people, two employed 11–29 people, one employed 30–49 people, and one employed 50–100 people. Three respondents had less than ten customers, two had 10–49, one had 500–1000, and one had more than 1,000 customers. There were no significant changes in their target markets: all nine companies still operated in Europe, three of them also operated in America, and one of them also operated in Asia. One company operated only in a regional/national market. Three companies had expanded remarkably through acquisitions and private funding after FICHe, whereas other companies had mainly continued with the same organizational structure and team. However, most of them saw high growth potential in the near future.

Seven of the nine companies reported having continued living lab and end-user involvement activities after FICHe, for example "to seek further validation of the solution" and "to assess the impact". One company even had established its own living lab for end-user testing. The two companies who did not continue living lab activities attributed it to a lack of funding. The companies were asked to assess the impact of living lab testing on market access and product/service development of their eHealth solution on a five-point Likert-type scale (1=no impact, 5=high impact). Regarding market access, three companies felt the impact was neutral, while four companies found living labs to have some impact. The impact on product/service development was found to be much stronger; five companies reporting high impact and three companies reported some impact. Retrospective feedback on the benefits of the living lab activities conducted during FICHe was highly positive:

> *"[The living lab] provides a unique opportunity to perform user-centered design activities, thus increasing the likelihood of having a final result that the target customers/users will adopt."* (Company 22)

> *"...some of the [end-user] feedback was of such a fundamental nature that it necessitated the radical change of some of the design principles. Without the living lab, we'd still be under the impression that our design was perfect."* (Company 58)

Finally, a desk follow-up study was conducted to verify the status of the 11 companies that did not respond to the follow-up survey. Based on the companies' websites and other online sources, all of them were still active in eHealth markets in 2018.

Discussion

This case study on the FICHe eHealth accelerator provides new insight to the scientific discussion on new business development within accelerator programs. The characteristics of the accelerators described in prior research (e.g., Cohen & Hochberg, 2014; Dempwolf et al., 2014; Hoffman & Radojevich-Kelley, 2012) apply to FICHe. The main design themes and elements of the accelerator model proposed by Pauwels and co-authors (2016) apply also to FICHe. Based on our research, the impact of the living lab approach in FICHe was substantial enough that we propose it to be added as a new

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design element to the generic accelerator model of Pauwels and co-authors (2016), as illustrated in Figure 2. The living lab approach in FICHe enabled the development of mature, market-ready solutions tested and verified with authentic end users. As we already discussed in related work, such a direct interaction with customers/end users for the purpose of gaining understanding of the real operating environments and testing of products has been suggested by Apodaca (2013).

According to the categorization of Pauwels and co-authors (2016), the design theme of FICHe was the "welfare stimulator". The primary objective of FICHe was to promote the use of FIWARE technology and stimulate European startup activity and economic growth. The main stakeholders in the welfare stimulator typically are government agencies, as was the case also in FICHe.

The first design element, "program package", included the following services in FICHe: mentoring, training, direct funding, and demo days. In FICHe, the second design element, "strategic focus", was European eHealth markets and the specific required FIWARE technology. The third design element, "selection process", comprised an online open call, an external review committee, and the key selection criteria of eHealth and team. The fourth design element in FICHe, "funding structure", was the EU Seventh Framework Programme funding. The fifth design element, alumni relations, included the FIWARE community in FICHe.

The new, sixth design element, "living lab", contains end-user involvement, authentic testing environments, various methods, and living lab expertise, which are the essential elements of a living lab (ENoLL, 2016; Robles et al., 2015). The inclusion of the new design element is inspired by the findings of this study, which explicitly show the usefulness of the living lab approach in the development of new products and services, thus supporting the prior research of other researchers (Almirall & Wareham, 2008; ENoLL, 2016; Leminen et al., 2012; Schuurman et al., 2013; Ståhlbröst, 2013; Robles et al., 2015). Our study also adds to the previous research in the form of new knowledge on the applicability of the living lab approach and elements (ENoLL, 2016; Robles et al., 2015; Ståhlbröst, 2008) in the new context of accelerator programs. Our findings show that a living lab is an applicable and significant design element within accelerator programs, yielding promising results in improving companies' market access, supporting the development of new, user validated, and desirable products, and creating recognized references for small companies. The main benefits for companies of using the living lab approach as a part of accelerator are summarized as follows:

- To improve business strategy and find the right business model and target groups.
- To gain understanding of customer needs and their use environment.

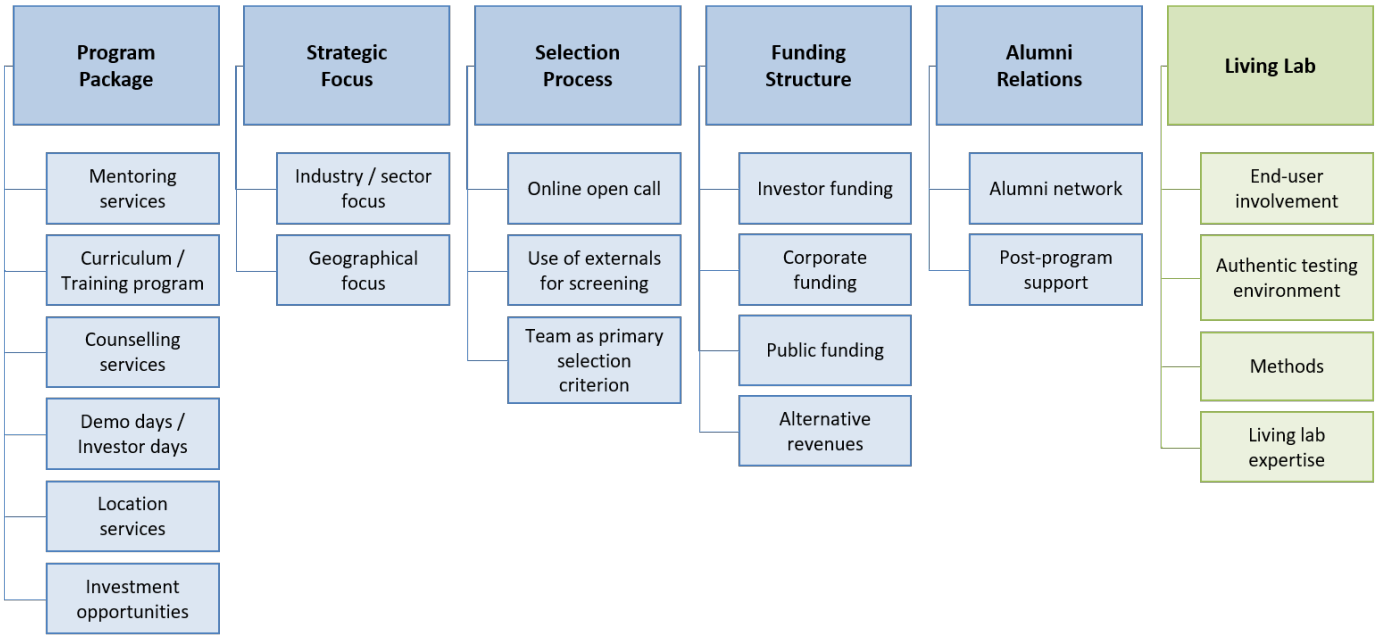

Figure 2. The accelerator model (adapted from Pauwels et al., 2016) extended to include the living lab element.

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- To increase a B2B network and gain visibility.
- To obtain a valuable reference of a customer case in an authentic context.
- To accelerate product and business development.
- To receive feedback from authentic users in the early phases of product development.
- To improve a product and obtain new development ideas or features.
- To learn how to deploy end-user involvement as an essential part of product development.

Impact on business development

The changes in the sizes of the teams (jobs created) and market focus were followed during FICHe from the business development point of view. These indicators were chosen because most companies had not yet entered the market hence the number of customers was not yet available. At the beginning of FICHe, the teams of the 20 finalists were relatively small. At the end of FICHe, almost all teams had grown and altogether 150 new jobs were created. We also followed the amount of private and public funding collected by the finalists during FICHe.

Besides funding, the 20 finalists highly valued the expansion of their networks, support received from the mentors, and feedback received from authentic end users in living labs. Networking with other companies and potential partners, and connections provided with the FICHe consortium were valuable. The finalists expanded their networks considerably by establishing close collaborations with each other, obtained good insight about European startups, and established new connections to investor forums and eHealth entrepreneurs across Europe. Participating in large business and networking events as well as media presence were considered as important ways to facilitate a company's market entry. The support and guidance from mentors were also highly appreciated, especially the support on growth processes, setting up a living lab, and sharing knowledge of eHealth and funding opportunities had a great impact on the companies. As discussed above, living lab testing facilitated the development of new business by identifying new customers and partnerships through interest and visibility gained with living lab activities.

FICHe also boosted the acceleration of the overall business development process of the finalists, brought the team members closer together, and fostered the visibility of the eHealth solutions. By being part of FICHe interactions with customers/end users to gain understanding of the real operating environments and testing of products (Apodaca, 2013), companies gained significant growth – while participating in FICHe, the most successful companies raised over €6 million of private funding. Moreover, some companies received, for example, public funding from the European Commission's Horizon2020 SME instrument. FICHe itself provided essential seed funding that allowed the startups to get off the ground. FICHe increased the reliability and business potential of the finalists in the eyes of the investors. However, not all companies were ready for or interested in investor rounds but preferred the strategy of achieving new growth by increasing the number of paying consumers (patients) and new healthcare customers (clinics/hospitals). In every phase, companies were able to continuously revise their business models, which allowed them to generate a validated business hypothesis. FICHe supported companies by linking them to SME instrument funding, which helped them to fund the development of the missing key parts of the solutions needed for international funding and markets. In addition, two finalists were acquired by a global corporation, one during and another after FICHe, and one finalist merged with a high-end technology supplier company.

As for international markets, the living lab approach enabled the finalists to test and validate their technology and business models and get in touch with international contacts. According to the companies, the importance of testing and validation was so great that it should be the first objective for an eHealth startup before entering international markets. For companies closer to the market entry, the timing of the living lab testing was perfect and boosted final development, market entry planning, and early customer validation. Most companies typically fell behind on their product development schedule – not because they were slow but because they kept on adding new features – but FICHe kept them in pace, encouraging them to develop a rapid prototype and validate the solution with authentic end users. The finalists focused more on European markets instead of local markets: different coaching sessions, business webinars and events as well as pitch deck consultants sharpened their views on business opportunities beyond domestic markets.

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Fourteen of the 20 finalists identified untapped business opportunities while participating in FICHe. For instance, the companies gathered new development ideas with patients and therapists, developed additional features to their solutions, leveraged rapid prototyping to start cooperation with other health service providers, found new markets for health monitoring by adjusting the solutions to new scenarios, won larger projects with several hospitals, and identified new hospital processes that they had not considered for their products before, thus creating new opportunities for the near future.

The follow-up survey complemented with the desk follow-up study shows that the finalists were still active on the market about a year after the conclusion of FICHe, intending to expand, and most of them continuing to use the well-proven practices of living labs and user involvement in the future development of their solutions. Retrospectively, most finalists valued the impact of the living lab approach as average or high for the development of their solutions as well as for the market access, which is remarkable from the point of view of indicating the usefulness of the living lab approach in the new business development within an accelerator. Thus, the program has wide-reaching economic impact yielding several companies with hundreds of employees.

Conclusions

This article explored new business development with accelerator programs in the form of a case study of the FICHe eHealth accelerator. FICHe differs from a typical accelerator in a way that there were specific elements such as the focus on eHealth solutions, the requirement to use the specific FIWARE technology, and the living lab approach, which in practice meant that end users were engaged in the development of the eHealth solutions from the early phase until the end of the accelerator. The 20 finalists benefitted most from the end-user involvement as the living lab testing was performed in the last phase of FICHe.

The results show that the 20 finalists gained significant growth. With the FICHe funding and services, the finalists created a significant number of new jobs, acquired several new customers and partnerships, and raised additional public and private funding. The combination of funding, coaching, and tangible outputs have contributed to the acceleration of the development of the companies' eHealth solutions. Due to FICHe, the companies also focused more strongly on the European market instead of a regional market. For companies closer to the market entry, the timing of the living lab activity was perfect and boosted the final development and early customer validation (Väinämö, 2016).

Based on the findings, all the 20 finalists valued the outcome of the living lab activity as highly significant. The living lab testing was regarded as an essential part of product development, in particular as an effective way to make the solutions market-ready. Moreover, the living lab activity was recognized as a valuable reference for companies' future marketing and sales, as it offered feedback from customers who had deployed the solution. In some cases, the living lab approach has merged into a company's sales strategy as an established new practice of first setting up a living lab with a new customer and then expanding the solution to the whole organization. The finalists experienced the living lab phase as very useful for the further development of their eHealth solutions. Therefore, almost all finalists expressed their willingness to continue living lab activities in their product and solution development, as according to them, it will allow to improve further their capabilities with the help of real usage environments and advice from professionals and patients. They reported having learned during the living lab phase how to co-create with users, to understand end-user needs, and how to refine their solutions on the basis of user feedback. Some companies also found new target groups for their solutions through the knowledge gained during the living lab activity. Living labs allowed some companies to contact their target end-user group for the first time, which they valued greatly. In several cases, testing with end users revealed issues that had not been detected earlier in the development of the solutions. To conclude, the living lab approach brought significant positive impact on the development of new businesses within the FICHe eHealth accelerator program. Therefore, we propose the generic accelerator model of Pauwels and co-authors (2016) to be extended with the addition of the living lab element.

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Appendix 1. The 20 FICHe finalists

ID	Team Size	Years of Operation	Description of Solution	Business Focus	Target Market
17	2–5	2–5	An online image analysis system for detection of osteoarthritis on X-ray images	B2B	Global
22	5–10	5–10	A wearable electromyography (EMG) muscle band-aid and a mobile application	B2B	Global
23	2–5	2–5	Web-based diagnostic support software for viewing interactive anatomic and pathologic imagery	B2B	Global
24	5–10	2–5	A multilingual service for matching international patients with healthcare practitioners	B2B/B2C	Global
28	2–5	<2	A multi-platform diabetes management ecosystem	B2B	National
29	5–10	<2	Biometric software for patient identification	B2B	Global
39	2–5	<2	A tool to streamline the referrals of cancer patients to clinical trials	B2B	Global
43	2–5	<2	A miniaturized respiratory monitor based on EMG	B2B	Global
44	5–10	2–5	A multi-device platform for the care of elderly people	B2B	Global
46	2–5	<2	A gamified software platform to deliver physical and cognitive therapy	B2B	Global
47	5–10	2–5	A system for locating patients in hospital	B2B	Global
53	2–5	<2	Virtual environments for the treatment of anxiety disorders	B2B	Global
57	2–5	<2	A technology-enabled medical nutrition therapy	B2B/B2C	Europe, Middle East, & Africa (EMEA)
58	5–10	5–10	An incontinence care system	B2B	National
64	2–5	<2	A 3D printing orthotics service for children with special needs	B2B	National
67	2–5	2–5	A mobile health platform specifically designed for people with breast cancer	B2B	Global
71	2–5	<2	A deep learning platform to detect degenerative brain disease in 3D-MRI	B2B	EMEA
76	2–5	<2	A remote collaboration solution for medical professionals	B2B	EMEA
77	<2	2–5	An online mindfulness platform to promote wellbeing	B2B	Global
79	2–5	2–5	A mobile application for the treatment of eating disorders	B2B	Global

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Keywords: startup, SME, accelerator, eHealth, living lab, open innovation, case study

The SDG-Check: Guiding Open Innovation towards Sustainable Development Goals

Justus von Geibler, Julius Piwowar, and Annika Greven

> *"There is nothing more frustrating than coming up with the right answer to the wrong question."*
>
> Tim Brown
> CEO and President of IDEO
> In *Change by Design* (2009)

The "fuzzy front end" of innovation is argued to be crucial for the success and sustainability impact of a final product. Indeed, it is a promising area of focus in efforts to achieve the United Nations' 2015 Sustainable Development Goals (SDGs), which provide a globally accepted framework for sustainability. However, the usability of the 17 goals and the large number of sub-goals represent barriers to innovation practitioners. Moreover, this early innovation stage proves to be a challenge for corporate practitioners and innovators, largely due to the concept's intangible, qualitative nature and the lack of data. To help overcome these barriers, this article proposes a four-stage approach for structuring the innovation process using an online tool called the "SDG-Check", which help assess an innovator's sustainability orientation in the early phases of product and service development. It is a semi-quantitative tool to gather and combine assessments by experts involved in innovation processes with implications for the United Nations' SDGs. Furthermore, this article presents our first experiences in applying the SDG-Check based on three living lab innovation cases. The results indicate that the tools can support and inspire a dialogue with internal and external stakeholders with regards to sustainability considerations in the early design stages of product and service development.

Introduction

In the light of human impact reaching planetary boundaries (Rockström et al., 2009; Steffen et al., 2015) and various political sustainability objectives, such as the Sustainable Development Goals (SDGs) formulated by the United Nations (UN, 2015), various stakeholders have called for an accelerated transition towards sustainability (e.g., Jacob et al., 2016; Jha et al., 2016). Research and innovation are crucial to address this challenge and change production and consumption systems.

Fichter and Clausen (2016) define innovation as the process of developing and implementing a radically new or significantly improved solution. Following this understanding, radical innovations are a change of frame, which implies a discontinuity with the past. Indeed, radical innovations are characterized as disruptive, destroying, or breakthrough (i.e., "doing what we did not do before"). In contrast, incremental innovations are improvements within a given frame of solutions (i.e., "doing what we already did, but better" (Norman & Verganti, 2014). In recent years, businesses have begun to open their innovation processes and engage societal actors (Howaldt & Schwarz, 2012) to achieve both radical and incremental innovations. Stakeholders, including both other businesses as external partners and consumers, are increasingly included in the development of products and services, even at an early stage of innovation. The concept of open innovation refers to the utilization of inflowing and outflowing knowledge across company boundaries to accelerate internal innovation (Chesbrough, 2003).

In addition, *sustainable innovations* have started to emerge worldwide as consumers are increasingly demanding sustainable products (Oksanen & Hautamäki, 2015). Although no universally accepted definition exists, sustainable innovations are usually associated with

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the support of sustainable development based on economically, socially, and environmentally sustainable principles. For example, Fichter (2005) defines a sustainable innovation as a "radically new or significantly improved technical, organizational, business-related, institutional or social solution that meets a triple bottom line of economic, environmental and social value creation. Sustainable innovation contributes to production and consumption patterns that secure human activity within the earth's carrying capacities".

The highest potential for shaping and designing innovations lies in the "fuzzy front end" of innovation, which is the very early stage of the innovation process. It begins when an opportunity is first considered worthy of further ideation, exploration, strategy formulation, and assessment, and it ends when a firm decides to invest in the idea, commit significant resources to its development, and launch the project (Dewulf, 2013). This applies especially to the sustainability potential of innovations (Hansen et al., 2009). Decisions made during this stage define a large share of the production costs and environmental impacts (Tischner, 2015). Furthermore, at this stage, decisions determine the path of the whole innovation process (Val-Jauregi & Justel, 2007), such as decisions on either incremental improvements or radical/disruptive interventions (Norman & Verganti, 2014).

However, implanting sustainability into innovation processes and assessing an innovation's sustainability impact are great challenges because of their complexity (e.g., Bonn & Fisher, 2011; Lozano, 2015) and ambiguity (Engert et al., 2016). For example, the concept of sustainability dependents on a number of (conflicting) interests (e.g., social, ecological, and economical) and parameters that vary across industries, countries, and time (Salzmann et al., 2005). Presumed sustainable solutions can thus cause *rebound effects* due to unforeseen consequences indirectly in other areas (Buhl et al., 2017). Hence, there is a need to deal with complexity in sustainable innovation development and in early innovation stages. In order to exploit the sustainability potentials in innovation processes and to enable interim innovation assessments based on a systematic and strategic approach, it is necessary to define appropriate requirements and to build a common sustainability vision that can guide the innovation process and thus minimize or eliminate risks as well as detect opportunities for sustainable development (e.g., Broman & Robert, 2017; Robert et al., 2013). Especially with an increasing radicalness of an innovation, the embeddedness of an innovation in individual, social, or cultural contexts of use is not ensured (Clausen et al., 2011). The SDGs could be the basis for the requirements that sustainable innovations face in order to achieve these ambitious goals. Furthermore, the approach of open innovation can significantly reduce the risk of innovations failing on the market, especially radical innovations in a difficult market or those facing technological uncertainties (Clausen et al., 2011).

Against this background, this article presents an approach to address sustainable development using a tool to assess sustainability orientation in the early stages of innovation based on the SDGs and stakeholder involvement. The concrete tool – the SDG-Check, which has been designed to identify and integrate relevant sustainability aspects in early stages of innovation processes – was proposed by Echternacht and colleagues (2016).

This article is motivated by the very first experiences made with the SDG-Check in three living lab projects in the early stages of the innovation process. The main objective of this article is to discuss the SDG-Check as a tool for sustainability orientation and assessment based on the SDGs in the fuzzy front end of innovation and together with various stakeholders. The related research question is: *How does the SDG-Check enable sustainability orientation and assessments in early innovation phases of innovation projects?*

In the remainder of the article, the approach and research methodology are described, including the background on sustainability assessment in the front end of open innovation processes. Furthermore, well-known innovation models are compared to analyze the structure of innovation processes of the early stage in particular. In the results section, the SDG-Check and experiences from applying the SDG-Check as an online survey tool are presented and discussed in light of the need for robust and practical sustainability assessments in transformative research and innovation processes. The article ends with conclusions and suggestions for further research.

Theoretical Approach

Open innovation in the early stages of innovation

Open innovation is especially relevant in developing product-service systems along with *users and stakeholders* (Liedtke et al., 2015). Involving stakeholder groups definitely requires interactive methods in interdisciplinary processes. Research on "co-creation" and a series of new business models and management tools, which include users in the innovation process, have lately been

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promoted by concepts of interactive innovation development, such as "open source innovation" (Muskat & Sylvester, 2012), "wisdom of crowds" (Surowiecki, 2004), or the "lead user" concept (von Hippel, 1986), as well as "transformation and transition design" (Irwin, 2015; Schmidt-Bleek & Tischner, 1995; Sommer & Welzer, 2014). Several interactive methods were developed with stakeholders and users, for example, to involve non-users and lead users in innovation workshops for sustainable-living innovations (Diehl, 2011), or web 2.0 tools to use collective intelligence (Leimeister, 2010). Based on the Agile Manifesto (a method to develop software in small steps, with little planning and strong user integration), Cooper (2014) proposes to strengthen user integration.

The integration of perspectives from users and stakeholders also offers the opportunity to integrate sustainability aspects, especially if a wide range of different stakeholder perspectives are considered. However, the integration of stakeholders also has limitations with regard to the consideration of sustainability. The users might have a limited perspective, rooted in their experience of daily routines, which do not promote radical or disruptive innovation (Kuijer & De Jong, 2011). Also, intense interactions with many stakeholders are time and resource-intensive, which hinders the innovation process. Furthermore, companies can be unwilling to receive and share knowledge and intellectual property (Søndergaard & Burcharth, 2011).

To enable more systemic innovation, it is important to identify and integrate relevant sustainability aspects as early as possible, given that product and service design at this stage are still adaptable and early-stage modifications are relatively low-cost compared to later modifications (see Figure 1). At the beginning of the process, the degree of freedom and influence on the project outcome is high, whereas little information is available and the cost of change is low. At later stages in the process, the availability of information is higher, but then the cost of change has increased (Verworn 2009). The challenge in the front end is created by the low amount and quality of information and certainty.

Structuring the innovation process

The multitude of models of innovation processes in the literature shows that there is not a single model that is transferable to all fields of application (Verworn & Herstatt, 2000). Innovation processes can be structured in different iterative phases, for example, from three to five or even nine phases (Geibler et al., 2016). However, in practice, it is difficult to comply with such models as they idealize and standardize the time flow of innovation processes.

The sustainability requirements could inform, for example, the design brief, which provides the foundation to the entire innovation and design process and can be seen as the report or summary of the investigation steps and the decisions taken in the front end, as shown in Figure 2 (Dewulf, 2013). It is a written description of a project – an agreement between the parties involved and a roadmap defining the various steps that will be followed (Phillips, 2004).

However, referring to Dewulf's (2013) stages of a design brief in the front end, it is not clear when an innovation is still considered as an early stage innovation and how this is connected to further innovation development,

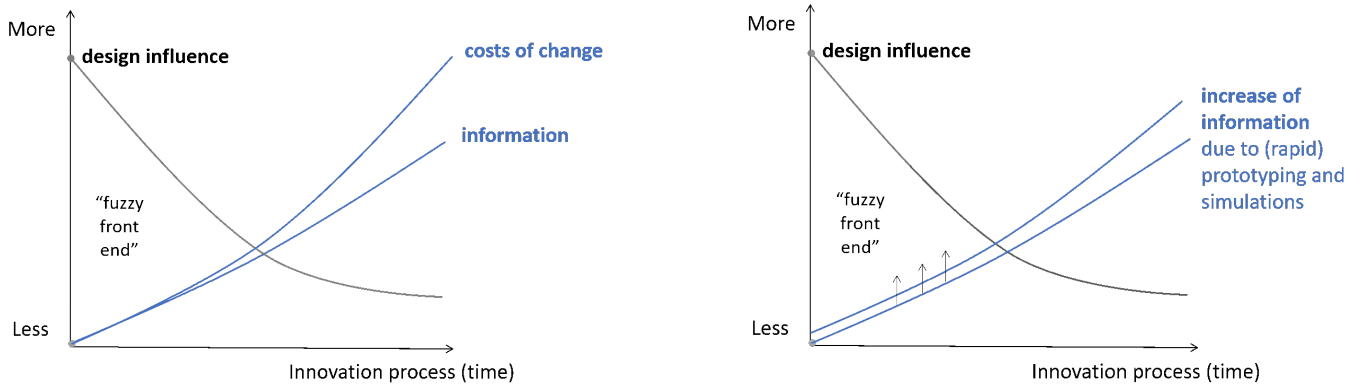

Figure 1. Evolution of influence, costs of changes, and information during the innovation process (left) and opportunities based on prototyping (right)
(Source: own illustration based on Ullman, 1997 and von Hippel, 1993, and modified by Herstatt & Verworn, 2001)

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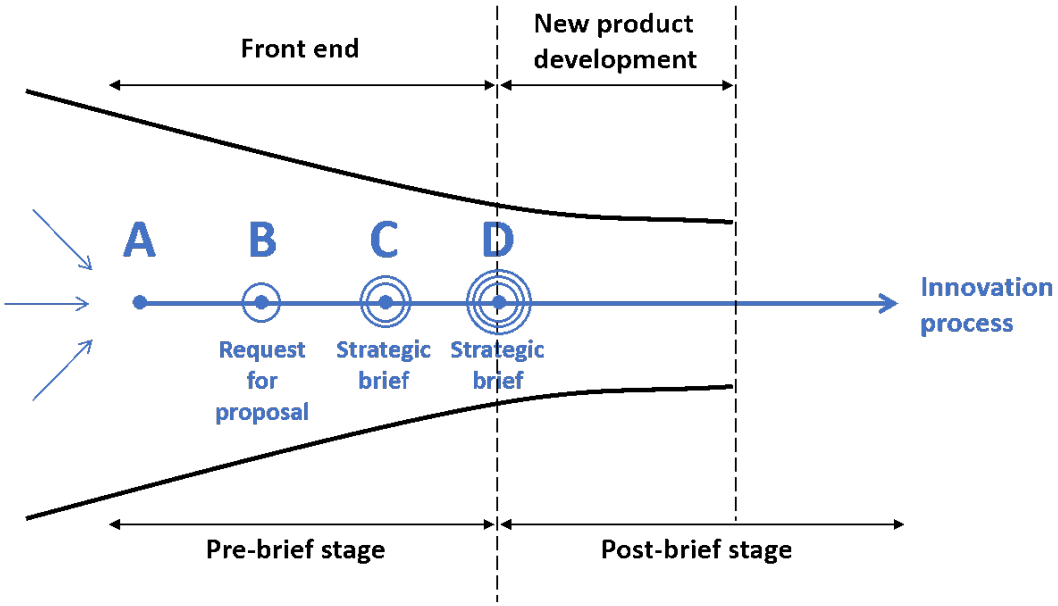

Figure 2. The various stages of a design brief in the front end of the innovation process (Source: Based on Dewulf, 2013)

that is why two internationally known models from the literature have been chosen and linked to each other to further analyze the temporal structuring of early innovation processes. The commonly used Stage-Gate process, originally described by Cooper (1990), has been chosen as the conceptual frame of the SDG-Check based on the evaluation of the experiences and discussions with relevant stakeholders. This model consists of several work phases, which are connected with each other via decision points at which the further implementation of the innovation process is determined. Due to the defined decision points, the Stage-Gate model (Cooper, 1990, 2001) presents a good starting point for the development of a structured approach for the integration of sustainability assessment in early innovation. In addition, the Innovation Readiness Levels (IRL) model (Geibler et al., 2016) is used to assess the maturity of innovations. The IRL model is derived from the Technology Readiness Levels (TRL) model (Mankins, 1995, 2009), which is a framework that has been used in many variations across industries to provide a measurement of technology maturity from idea generation to commercialization and understanding of required capabilities and resources. As the innovation process is not only limited to technological development but should also include the interaction of users or stakeholders for example, the TRL model has been extended to innovation readiness levels. With its nine levels, the IRL model presents a rather detailed approach to assess the maturity of innovation, whereas the Stage-Gate model describes the innovation process in a broader manner. Both models will be linked and used as a foundation to address the front end of innovation.

The four phases of the Stage-Gate model are: 1) the preliminary investigation, 2) the detailed preliminary investigation, 3) prototype development, and 4) the field test (Liedtke et al., 2015). In the case of an "ideal" procedure, the process can be structured and sectioned by five different points of decision-making (so-called "gates") (see Figure 3). According to Grönlund and colleagues (2010), the front end of innovation is defined as a phase where opportunities are discovered and ideas are generated, as opposed to later stages, which concentrate on a concrete concept development, testing, and commercialization. This can be linked to the preliminary investigation phase including the two decision points "project estimation" and "project decision", which are concerned with the conceptual definition of the innovation in terms of function and field of application (see Figure 4). The evaluation of those two gates particularly intends to ensure the general orientation of the innovation towards sustainability goals and the identification of sustainability effects (Echternacht et al., 2016).

The IRL model (Geibler et al., 2016), derived from the TRL model by Mankins (2009), divides the innovation process into nine individual and distinct innovation readiness levels (Geibler et al., 2016; see Figure 5). The

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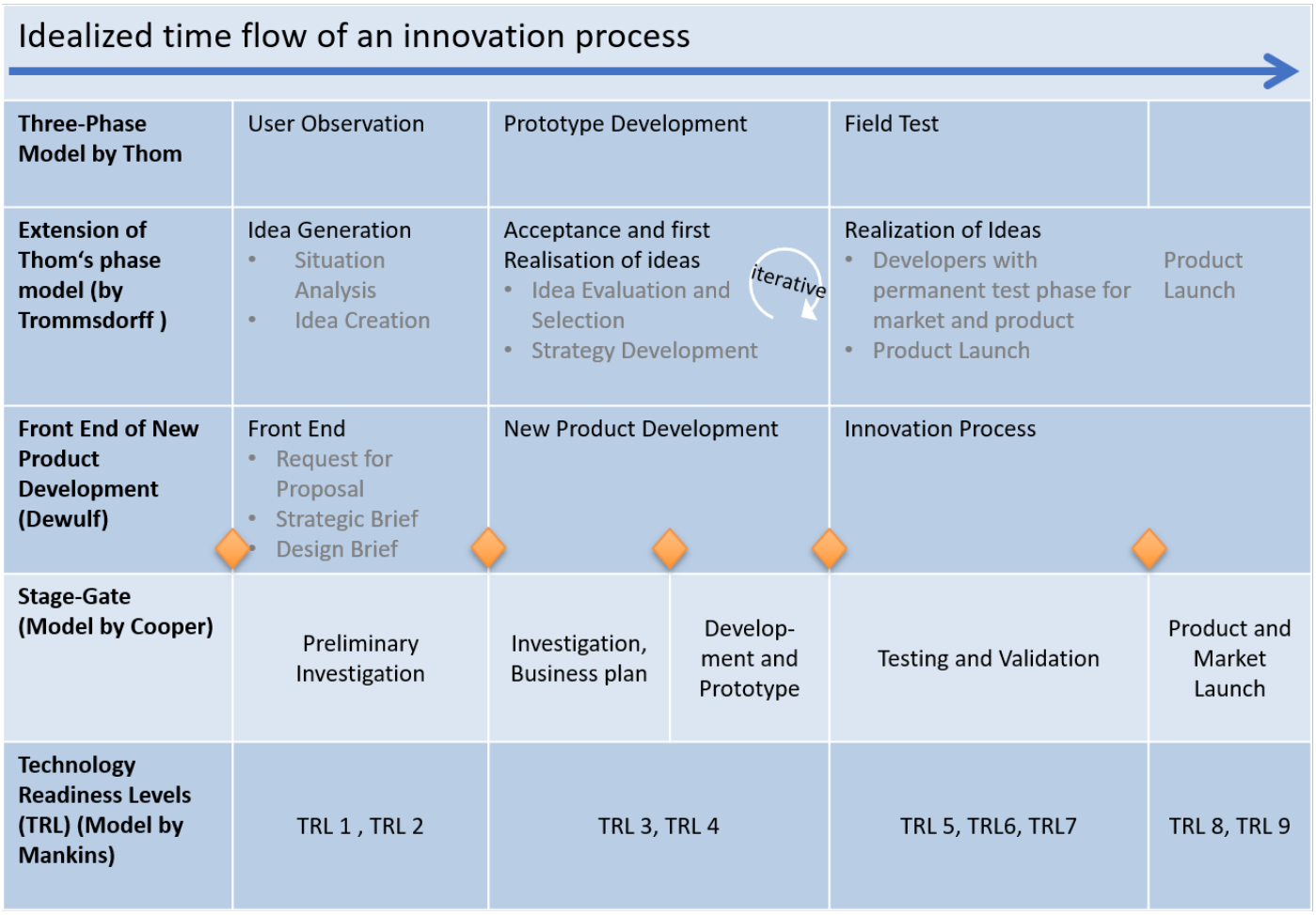

Figure 3. A comparison of the phases of innovation models (Source: own illustration based on Geibler et al., 2016)

TRL model is used internationally for sustainable innovation processes (Nakamuraet et al., 2013), and it provides a common understanding of the maturity of an innovation (Geibler et al., 2016). The levels can be connected with the points of decision-making in the Stage-Gate model, or rather the first two gates that have already been linked to the early stage of an innovation. In the first decision gate "project estimation", an overall estimation is conducted to identify existing needs or expectations of users and the users are observed to gather relevant data (Geibler et al., 2016). This conforms to the first innovation readiness level, as it consists of observing and reporting basic principles regarding the innovation. In the "project decision" gate, these data serve as a foundation to determine whether a new product or system solution will be developed. If it is decided to proceed with the project, the need that the innovation addresses is defined. This step aligns with IRL 2, as a broad idea of an innovation or application concept is formulated (Geibler et al., 2016).

As data availability and resources for assessment are limited in the early stages of an innovation, related sustainability assessments tend to be rather simple and only supportive for awareness raising, general orientation, and the broad identification of sustainability effects. Consequently, checklists can be used as an assessment instrument. For example, regarding the first gate, "project estimation", it can be asked to what extent the innovation can contribute to one of the UN's 17 SDGs. A minimum number of criteria should be defined in order to satisfy the sustainability assessment positively, for example, that at least three SDGs are positively influenced. At the second gate, "project decision", these can be substantiated by using the sub-goals. In principle, this ensures an improved assessment of the potential to contribute to a sustainable development. With the help of such an instrument, the developer becomes aware of the goals that can and should give direction to the innovation process. In addition, at this point the estimation of potential can also

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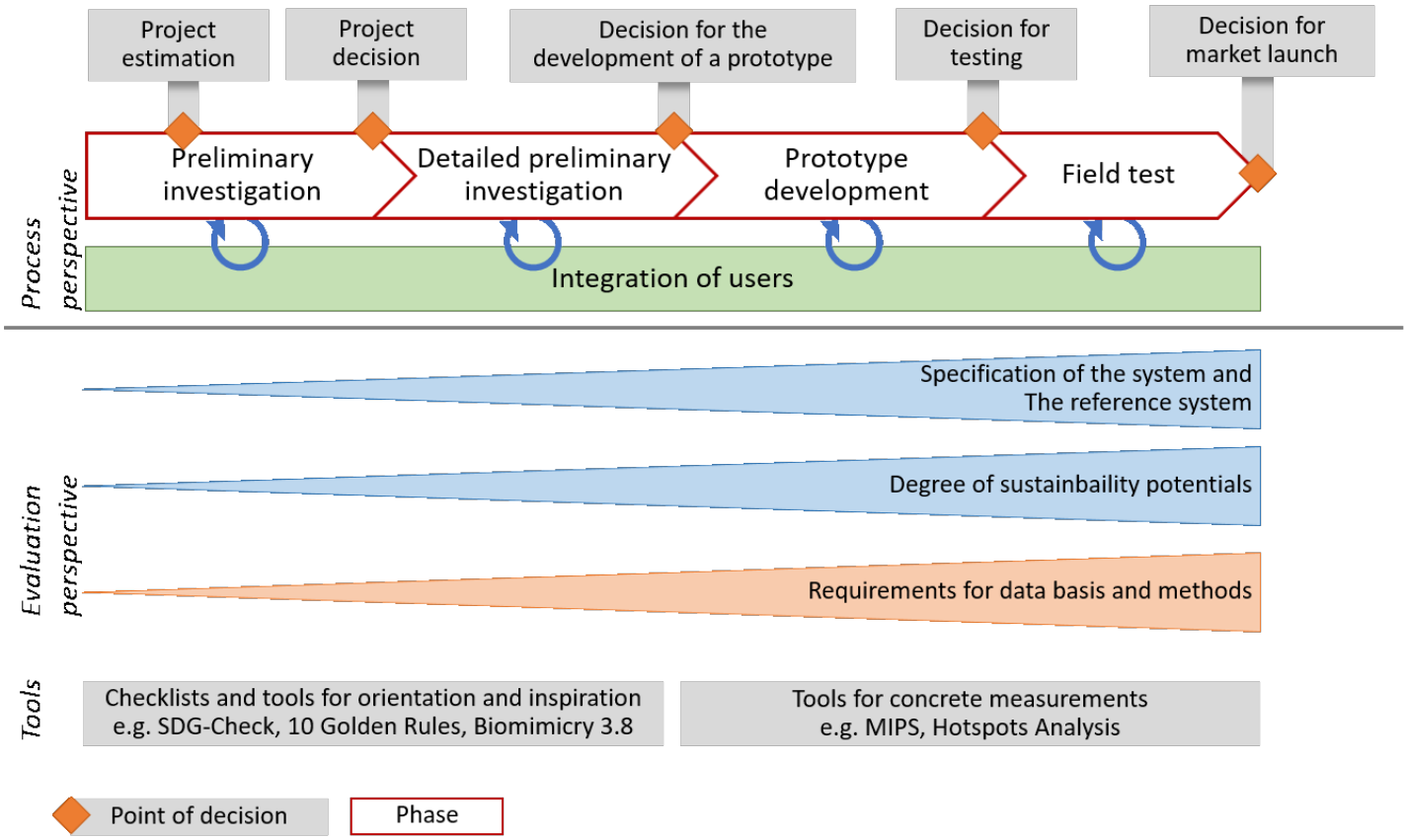

Figure 4. Phases and gates in the innovation processes and evaluation (Source: translated from Geibler et al., 2016)

serve the developers as inspiration for the description of the target market and the target group of the innovation.

Furthermore, *assessing the sustainability* within innovation processes requires defining and describing both the innovation system and the reference system. In addition, stakeholders' needs and objectives must be defined for this analysis, for example, based on a guiding vision (IISD, 1997):

1. Describing the *innovation system* allows identifying and evaluating the innovation's sustainability in terms of its techno-physical, usage system, and cultural levels (see Figure 6; Paech, 2005). The techno-physical level describes the direct effect of the innovation's production or development, including direct effects upstream, for example, the technical eco-efficiency improvements of a car. The usage system describes direct and indirect effects of the innovation and during the usage phase, such as the efficiency in use gained by product-service systems such as car-sharing models (Buhl et al., 2017). The cultural level describes the innovation's cultural effect. For example, questioning the need for mobility and thus substituting the underlying "want" with a different solution, such as satisfying the want for recreation not with far-away holiday destinations but with near-by holiday destinations and thus forgoing (most of the) mobility services. Innovations, which are highly culturally effective, have more impact potential (for cultural-institutional change) than innovations, which only have technical effects (for technical change). This means, for example, that eco-efficiency gains can be achieved with relatively little effort in the new product development stage of an innovation process. However, to tackle root problems at higher system and cultural levels, the problem needs to be already integrated in the front end of the innovation process. After this crucial phase only technical eco-efficiency improvements or product redesign are possible (Dewulf, 2013), not radical/disruptive changes (Norman & Verganti, 2014).

2. Further, comparing the *innovation system* and the *reference system* (e.g., available products or other innovative concepts) allows estimations of the potential

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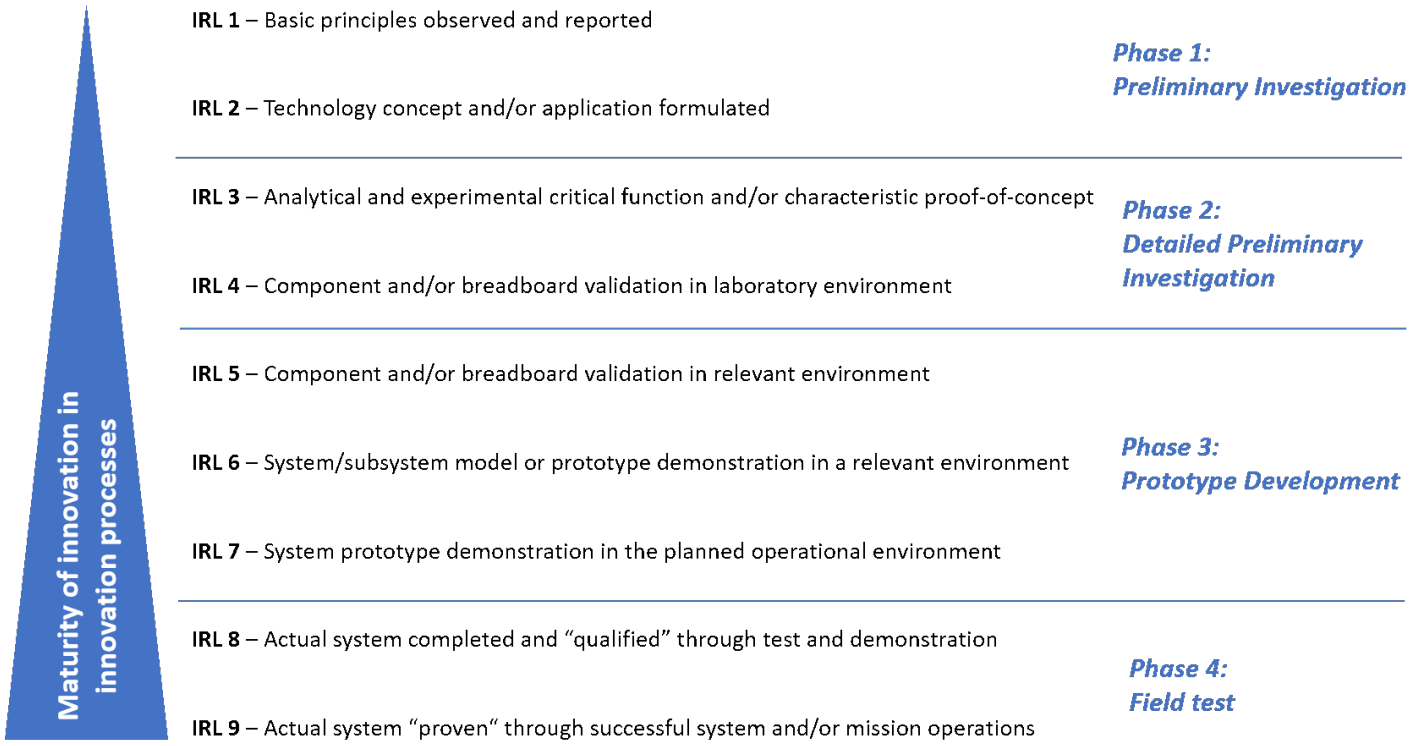

Figure 5. Innovation Readiness Levels in a Living Lab (Source: own illustration derived from Mankins, 2009)

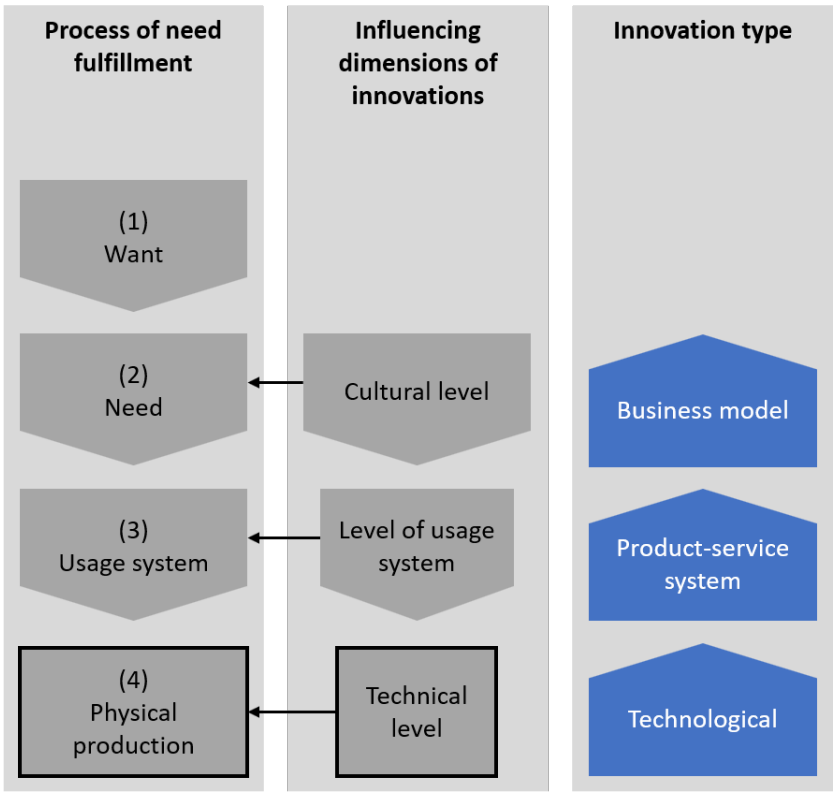

Figure 6. Three levels of the innovation system (Source: Hansen, 2009, based on Paech, 2005)

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for change towards sustainability. If the innovation is already positioned on the market, sustainability and change "effects" can be assessed and analyzed (Hansen et al., 2009).

3. Assessing sustainability within innovation processes, *stakeholders' needs and objectives* must be defined. In this process, both stakeholder groups should be included: actively involved groups (e.g., employees and users with individual interests such as well-being and satisfaction) as well as passively involved or "affected" groups (e.g., administrative stakeholders or future generations with collective interests such as ecological concerns).

This assessment allows insight and inspiration about stakeholders' needs and desires to be gained from many different and even conflicting viewpoints and opinions, for example those sought from brand promise, technology, societal, and ecological trends as well as mere vision of renewal.

In order to manage this complexity in the front end of innovation, Val-Jauregi and Justel (2007) suggest different tools, methods, and techniques, such as creativity techniques, scenarios, technology scouting, and market and opportunity analyses. Furthermore, there are specific methods and tools that enable exploring individual stakeholder concerns in the early stage of an innovation. Diefenbach and Hassenzahl (2017) have chosen seven psychological needs as the starting point for the innovation process, for example as facilitated by Need Cards (Hassenzahl et al., 2013). Similarly, van Dijk and Hekkert (2014) introduced the Vision in Product Design (ViP) method that primarily explores the meaning of a product or service in relation to a future context. Thereby, these methods allow innovators to, for example, question and rethink the traditional business models and break with traditional innovation routines. In addition, there are methods and tools that specifically focus on sustainability in the early stage of an innovation, such as Biomimicry 3.8 (Baumeister et al., 2013) or the 10 Golden Rules (Luttropp & Lagerstedt, 2006). Both of these examples serve as guiding tools towards sustainable product design. Geibler and colleagues (2016) suggest an SDG-Check for the assessment of sustainability potentials, referring to the SDGs. The SDGs are broadly defined and extend from fighting poverty to improving education and health to mitigating climate change as well as protecting the oceans and ecosystems. Under the title "Transforming Our World: The 2030 Agenda for Sustainable Development", the UN member states created a catalogue of 17 goals and 169 subordinate goals; the realization of these goals by 2030 is voluntary, but for the first time it is universally valid, equally for developing, emerging, and industrialized countries (UN, 2015).

Research Methodology

The research process involved three main phases:

1. Development of the SDG-Check as an online tool
2. Application of the SDG-Check in three cases
3. Evaluation of the SDG-Check application

Phase 1: Development of the "SDG-Check" as an online tool
The SDG-Check was initiated in the living lab research project INNOLAB (2018) and was based on a literature review focusing on conceptual and methodological understanding of sustainability assessments within open innovation processes (Echternacht et al., 2016). Questions and answer options were integrated in an online survey tool. In the results section of this article, the development of the SDG-Check is described, focusing on the functional requirements and the concrete steps.

Phase 2: Application of the SDG-Check in three cases
The SDG-Check was applied in three innovation projects within three German living labs (2016–2017) (see Table 1). The objective of the innovation projects was to co-create and test (digital) assistance systems, which encourage sustainable consumption in the fields of living, retail, and mobility. The innovation process was facilitated and guided by different living lab methods including the SDG-Check. The SDG-Check was applied by three to seven project members in each project involving practitioners from small and medium-sized enterprises (SMEs) and researchers. This enabled researchers to compare, for example, different perspectives on sustainability within each team. Furthermore, the SDG-Check was applied as early as possible in the project (in the concept phase) as well as at a later stage (in the prototype phase). This enabled researchers to compare results based on different temporal stages, for example (see Kahl et al., 2017; Krein et al., 2017; Meurer et al., 2017).

Phase 3: Evaluation of the SDG-Check application
After the application of the SDG-Check, and together with the innovation project members, the effectiveness and efficiency of the SDG-Check was evaluated. This analysis is based on a written survey with the three project leads and a discussion in a workshop within the project teams (13 participants).

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Table 1. Overview of the three innovation projects and the application of the SDG-Check

Project Name	Innovation Objective	SDG-Check Participants	SDG-Check Application Phase
Living	An assistant system encourages sustainable ventilation behaviour to reduce energy consumption and to avoid mould in private households.	5 participants involving practitioners from SMEs and researchers	Concept phase (2016) Prototype phase (2017)
Retail	An assistant system encourages sustainable shopping behaviour in a supermarket (point of sale).	7 participants involving practitioners from SMEs and researchers	
Mobility	An assistant system encourages sustainable mobility behaviour for the elderly.	3 participants involving practitioners from SMEs and researchers	

The survey was carried out in German amongst the innovation managers of three living lab projects in Germany. The questionnaire objective was to gather practical insights and experience on the application of different methods and tools (including the SDG-Check). The aim was to understand their impact on success as well as future potentials and limitations. The questionnaire included both closed-ended and open-ended questions (Table 2).

At the end of the innovation project, the three project teams (including practioners) discussed the experiences with the living lab methods including the SDG-Check during a workshop. The guiding questions of the workshop included: What are the results of the SDG-Check? How do you evaluate the relevance of the method after the application? What can be improved? The results of the workshop were summarized in the project reports (see Kahl et al., 2017; Krein et al., 2017; Meurer et al., 2017).

Table 2. Questionnaire framework for the SDG-Check evaluation (Source: Geibler et al., 2018).

Questionnaire Type and Focus		Guiding Question	Five-Scale Ranking
Closed-ended questions focusing on methods effectiveness	User integration	*How relevant are the methods you use to improve the chances of exploitation and sustainability orientation?* Please score the methods according to the given criteria.	(--) very insufficient (-) insufficient (0) neutral (+) good (++) very good (n.a.) not applicable; no or insufficient data available
	User context integration		
	Social aspects		
	Ecological aspects		
Closed-ended questions focusing on methods efficiency	Cost efficiency	*How user-friendly and efficient are the methods?* Please score the methods according to the given criteria.	
	Technical efficiency		
	Time efficiency		
	Usability		
Open-ended questions	Advantages	*What were main advantages, limitations, and challenges of the method during your application?*	
	Limitations and challenges		

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Results and Discussion

Description and development of the online tool "SDG-Check"

The SDG-Check focuses on potential effects an innovation could have regarding the 17 goals and their sub-goals. The SDG-Check is designed to raise consciousness about these goals and their thematic diversity, so that the stakeholders are more attentive to options to integrate these goals in business modelling, for example. The tool development (Echternacht et al., 2016) was framed by the following requirements:

- The tool's *objective* is to identify potential sustainability effects (risks and opportunities) of an innovation within (early-stage) development processes. Furthermore, the tool should enable orientation and a common understanding of sustainability goals and to inspire ideation processes as well as business models. This means that the tool will not be able to measure specific sustainability aspects, such as carbon dioxide emissions.

- The tool's *target group* is members of multidisciplinary innovation teams, such as engineers, designers, and sustainability and non-sustainability experts. The results of the tool are based on self-assessment by individuals or groups.

- The *usability criteria* (ISO 9241-210, 2010) for the tool are the following: results of the SDG-Check should be transparent and comparable, for example, with assessments of users or with later assessments; the application should be intuitive and understandable; sustainability knowledge should not be required; and the time needed for the individual tool application should be less than 20 minutes.

As a result of these requirements, the SDG-Check tool is built on an online checklist and a stepwise approach with two levels of detail focusing on the 17 SDGs (level 1) and their sub-goals (level 2). The goals are evaluated based on a seven-step scale ranging from -3 (severe risk) to +3 (high opportunity).

Step 1 (level 1) of the SDG-Check serves to estimate whether the innovation creates opportunities or risks concerning the 17 SDGs. To do this, it is estimated whether the innovations have positive or negative potential with regard to the 17 SDGs using a seven-step scale. The SDG-Check's first step is shown in Figure 7.

Step 2 (level 2) of the SDG-Check can be applied during the innovation process. Here, the focus is on the sub-goals of the SDGs and, for usability reasons, only for a selected number of SDGs. The selection covers the six main goals of Step 1 that were evaluated with the highest values related to opportunities (3 goals) and risks (3 goals). The participants evaluate the sub-goals in terms of opportunities and risks also using the seven-step scale (ranging from -3 to +3). For the aggregation of the single assessments at goal level the Chance-Risk-Value (CR-Value) is used as a means of the single assessment values at sub-goal level. As an example, Figure 8, illustrates Step 2 with sub-goal questions of the SDG 12 (Responsible consumption and production). The questions for the other sub-goals can be found in Echternacht and colleagues (2016).

Results of the SDG-Check

The SDG-Check results were assessed in three innovation projects for both Steps 1 and 2. For each project, the results are based on the self-assessments by the participants and calculated as CR-Values as well as value ranges. This method enabled an illustrative SDG ranking, which was presented to the participants for further discussion. As an example, Figure 9 and Figure 10 illustrate results of the SDG-Check from the innovation project "Retail" involving assessments of seven project members.

The results illustrate that the most significant opportunities and risks can be easily identified. In the case of the innovation project "Retail" (see Figure 9), the most significant opportunities of the evaluated shopping assistance system are linked to the goals "Responsible production and consumption", "Life below water", "Industry and innovation and infrastructure", and "Good health and wellbeing". The results of Step 2 present the views of the participants concerning the relevance of related sub-goals of the SDGs. For example, as Figure 10 shows, the innovation can contribute to SDG 12's sub-goals "Efficient usage of natural resources" and "Restoring sustainable resource management and protection of marine and costal ecosystems" (Kahl et al., 2017). Sub-goals also can be identified as minor risks, which means that the innovation could affect them negatively. In the innovation project "Retail", this included, for example, "Increasing the wealth of the poorest 40 % of the population" and "Raising exports to developing countries". The figures also highlight those goals or sub-goals for which the team has divergent viewpoints.

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Figure 7. Step 1 of the SDG-Check (Source: Geibler et al., 2016; specification of the SDGs based on UN, 2015).

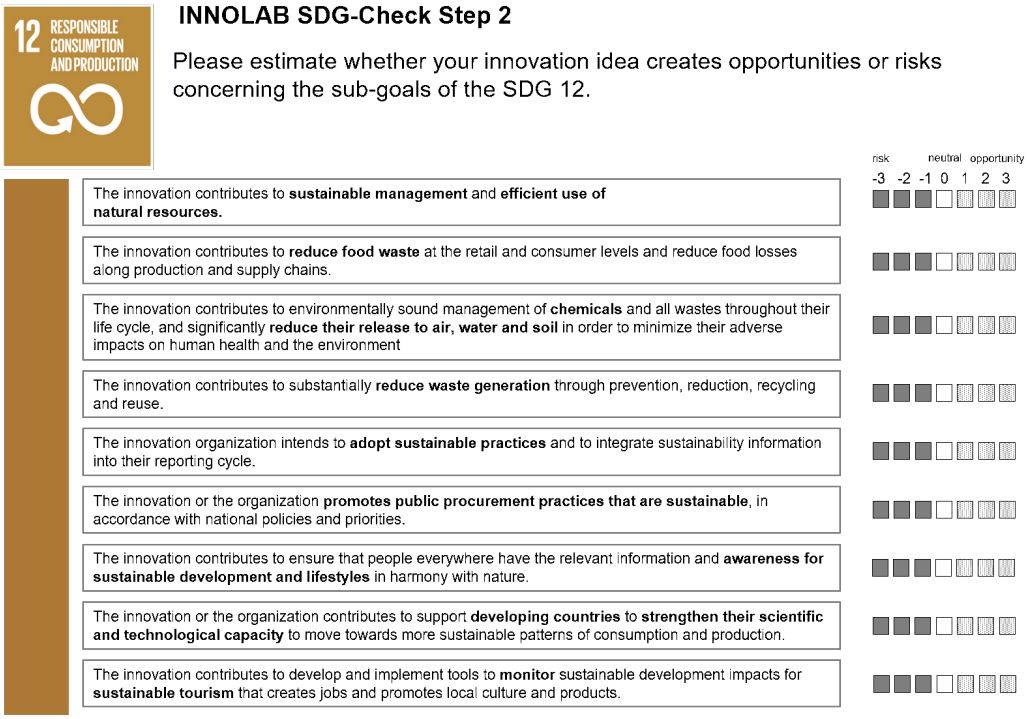

Figure 8. Step 2 of the SDG-Check, taking the example of SDG 12 "Responsible production and consumption" (Source: Based on Geibler et al., 2016; specification of the SDGs based on UN, 2015)

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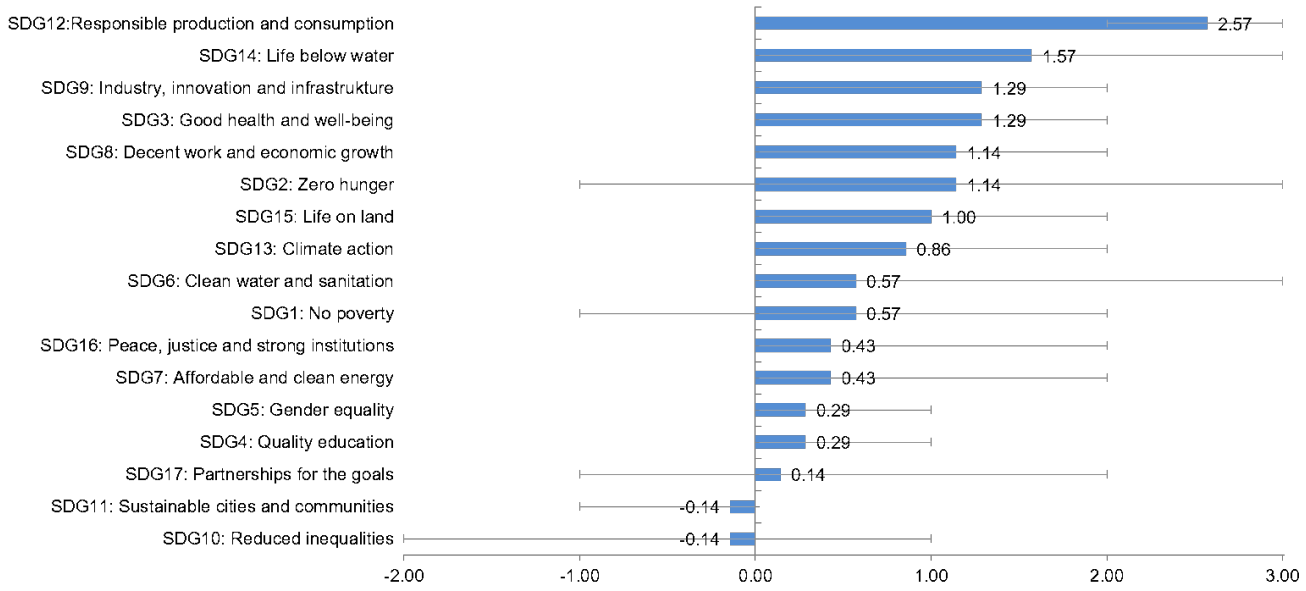

Figure 9. Results of the SDG-Check (Step 1) in the innovation project "Retail" (Source: translated from Kahl et al., 2017)

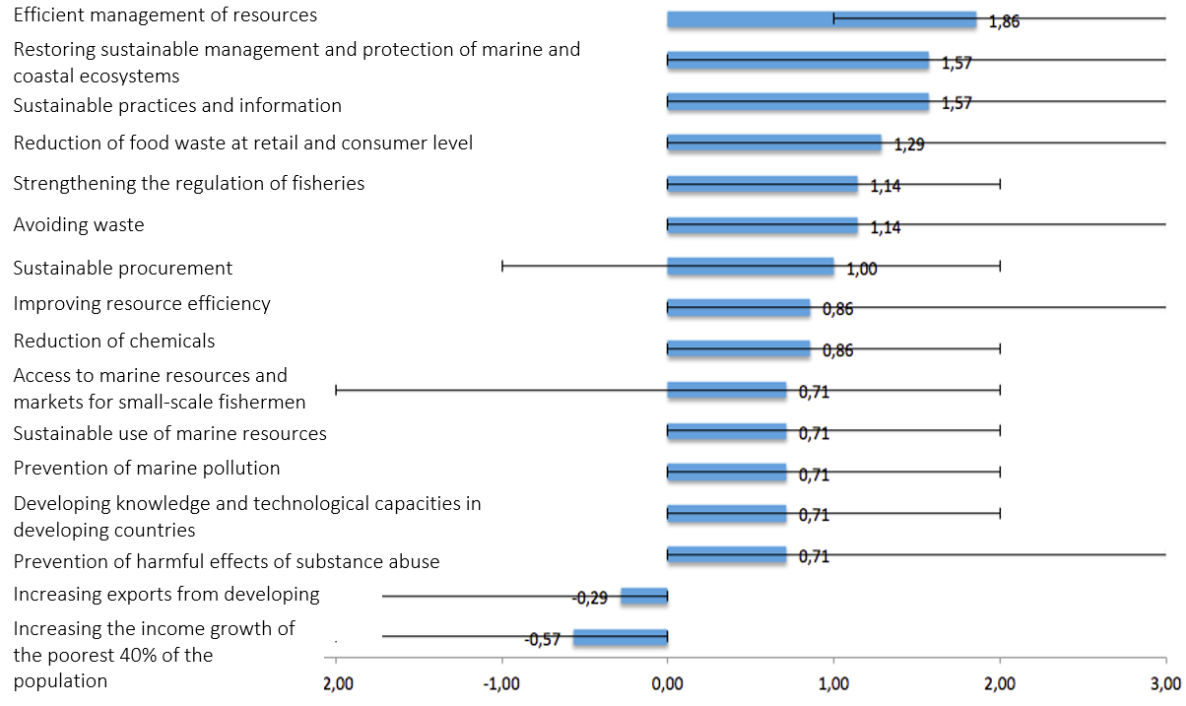

Figure 10. Results of the SDG-Check (Step 2) in the innovation project "Retail" (Source: translated from Kahl et al., 2017)

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Evaluating the SDG-Check

Based on the experience of the three innovation projects collected by workshop discussion and survey results, the overall finding points out that the application of the SDG-Check provides effective results and is very user-friendly. For example, the workshop discussion highlighted that the broad SDGs directed the innovation projects towards sustainability, without being too restrictive. Furthermore, the workshop discussions made clear that addressing the SDGs helps to cope with complexity and ambiguity because the SDGs have a very broad consensus and high legitimacy and thus built confidence and trust within the innovation process.

The survey results illustrate positive effectiveness and efficiency of the SDG-Check (Table 3). The findings indicate that the SDG-Check is a cost-efficient tool, which provides hints for ecological and social improvements. Finally, the SDG-Check is easy to use, not very time consuming (less than 20 minutes) and straightforward based on a simple and standard evaluation scheme (with a scale between 1 and 7).

Implications

Implications for practitioners

Based on the workshop discussion, the following implications for practitioners can be summarized:

- The SDG-Check enabled a harmonized communication about sustainability within the project team with sustainability and non-sustainability experts. It has been a platform for the development of a common understanding of sustainability and sustainability goals. Thereby, it supported decision-making in the teams based on semi-quantified results of the SDG-Check. As a consequence, the SDG-Check could inspire and encourage new business models and sustainability thinking in innovation processes.

- The SDG-Check is not very time consuming (less than 20 minutes) and is intuitively based on a simple and standard evaluation scheme with a seven-point scale. However, without an introduction and explanation, the SDGs can be abstract and unstructured and reduce the motivation to deal more closely with the SDG theme/sustainability and to take appropriate measures for product design into consideration.

- The complexity of the 17 goals and 169 targets could lead to a mental *overload* and demotivation, depending on the user's knowledge on the SDGs. However, the SDGs' communicative potential is very high because of their international recognition. They can be combined with other company-relevant methods (such as the SDG Compass; sdgcompass.org) and can serve as the basis for an enterprise-internal sustainability strategy. Additionally, the SDG-Check can support learning processes on the SDGs.

Table 3. Evaluation of the SDG-Check application (based on questionnaire survey with project leads) (Source: Geibler et al., 2018)

Effectiveness	**Score***	**Efficiency**	**Score***
User integration	0	Cost efficiency	++
User context integration	+	Technical efficiency	+
Social aspects	0	Time efficiency	+
Ecological aspects	++	Usability	++

*Legend: (--) very insufficient, (-) insufficient, (0) neutral, (+) good, (++) very good; the assessment is based on the mean value.

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Implications for researchers

Based on the workshop discussion, the following implications for academics can be summarized:

- The SDG-Check enables initial quantitative evaluation results at the very early innovation stage. This quantification can complement qualitative assessments, for example, to enable comparisons of different innovations (e.g., service models versus ownership models), different team members (e.g., designer vs. engineer), and different innovation phases (e.g., early phase vs. later phases).

- An in-depth sustainability analysis (e.g., environmental or social live circle assessment) could not be performed with the SDG-Check. For an effective sustainability analysis (e.g., with the hotspot analysis; Liedtke et al., 2013) this would be sensible: the selection of the goal and targets does not necessarily have to be the most significant sustainability potential of the innovation. The selection is based on a self-assessment, which can be used as a basis for the further dialogue and should be evaluated by other experts.

- In the context of innovation management, the application of the SDG-Check could be improved by embedding the tool into a holistic innovation and design culture, for example, one that is based on human-centred design and design-thinking approaches (e.g., Norman, 2013). This can allow for more effective combining of different tools and methods.

- Although the usability of the SDG-Check was evaluated positively, there are opportunities for improvements. For example, the findings encourage intuitive explorations of the SDGs and how they relate to an innovation project by providing more interactive qualities for innovators, for example, by involving gamification principles (e.g., Chou, 2016). Therefore, the tool could be delivered in a non-traditional setting aiming at an experiential and holistic learning approach, such as on drawing on the didactic approach of open-didactic exploration (Bliesner et al., 2014).

- To further support a common understanding of the fuzzy front end of innovation and its process, the tool could include extended questions focusing on the identification of the innovation readiness level as well as the degree of novelty (i.e., incremental vs. advanced or disruptive vs. radical).

Conclusion

The assessment of the early product and service design phases is of major importance since these early stages influence a high share of the cost spent for a product or service (i.e., production costs, maintenance costs, and end-of-life costs). Similarly, the environmental and social potential of an innovation are also determined in this front end of innovation development. Considering the complexity of technological implications on sustainability, it is necessary to assist innovators in developing and implementing technological innovations and the consideration of sustainability.

Two internationally known models – the TRL model by Mangans (1995) and Cooper's (1990) Stage-Gate model – have been combined in order to structure the open innovation process and guide sustainability assessments. This new model has been used to clearly define the fuzzy front end, where the identification and integration of sustainability aspects and stakeholder views is most important.

The presented SDG-Check is being developed in the research unit "Innovation labs" at the Wuppertal Institute to support the identification of the most relevant SDGs in the early stages of product and service innovation processes. Building on an online checklist and a participatory stepwise approach, the tool considers two different levels of detail: one at the level of 17 goals and another at the level of sub-goals. The digitalized processing of data enables the assessment of the large number of data entries and aggregations and comparisons of experts' views on the risk and opportunities of the innovation with regard to the SDGs. However, the single application of the assessment tool alone will not be sufficient to support sustainable innovations. Along with evaluations, it is necessary to develop a responsibly minded innovation culture that integrates sustainability as an inherent innovation objective. A corporate culture that promotes the "ability to learn" – the central point for our ability to innovate more sustainable production and consumption patterns.

Future research can be conducted based on a broader application of the SDG-Check in other cases. Hereby, the SDG-Check should be more extensively compared to other approaches focusing on innovation development at an early stage, such as Biomimicry 3.8 (Baumeister et al., 2013), the 10 Golden Rules (Luttropp

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& Lagerstedt, 2006), the Need Cards (Hassenzahl et al., 2013), AttrakDiff 2 (UID, 2018), and Vision in Product Design (Dijk & Hekkert, 2014). Also, pairing the SDG-Check with other tools, workshops, or services on a public platform like What Design Can Do (WDCD, 2018) or Ashoka Changemakers (Muskat & Sylvester, 2012) should be considered further.

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Keywords: sustainable development goals, SDG-Check, open innovation, living lab, sustainability assessments, fuzzy front end of innovation, sustainability inspiration

Exploring Participation Needs and Motivational Requirements When Engaging Older Adults in an Emerging Living Lab

Tiziana C. Callari, Louise Moody, Janet Saunders, Gill Ward, Nikki Holliday, and Julie Woodley

> *"You know, having participated in that little bit of research, it obviously links into something else, and it could be nice if you can hear about it and think: 'Well, I feel quite proud of that, because I helped'.*
>
> Research participant interviewed for this study

There is a growing body of literature regarding living labs, which are seen as an effective way to develop and evaluate research for novel products and services with the actual end users. With growth in the living labs model, there is an increasing need for guidelines to steer and support the set-up and maintenance of initiatives, and to facilitate relationships and engagement with stakeholders and users in this context. This study seeks to address this need, in part, by exploring the needs, expectations, and motivations that older adults have in relation to research participation in an emerging living lab. This work is part of a wider research project to develop an integrated framework to guide emerging living labs. Eight semi-structured interviews were undertaken with six residents and two family members from two residential settings for older adults that were collaborating to establish a living lab environment. A concept-driven coding frame supported the coding and analysis of the interview transcripts. The results provide insights in relation to participant motivation to take part in research, and they identify some issues of concern for participants, both residents and family members, related to living lab initiatives. As a first step in developing a successful living lab culture of collaborative research, this study has demonstrated that open discussion with residents and their families should continue to guide processes and research design as the emerging living lab initiative continues.

Introduction

As the European Network of Living Labs (ENoLL) highlights, living labs are defined as "user-centred, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" (ENoLL, 2006). Research has shown that living labs and living lab initiatives have been conceptualised in different ways, with some researchers arguing for the need to reconcile them under a more consistent definition to address diverging theoretical and methodological approaches (Habibipour, 2018; Leminen et al., 2012; Schuurman et al., 2015; van Geenhuizen, 2014; Yazdizadeh & Tavasoli, 2016). The need to have formalizsed guidelines, particularly in terms of ethical processes to guide and support the relationships and engagement with the living lab stakeholders and users, has also been highlighted (Pino et al., 2014; Sainz, 2012). The need for a guiding framework is due, in part, to the nature and characteristics of living labs and the different ways in which they develop and emerge. They are heterogeneous; for example, with different research or development foci, they draw on different participant groups and settings and involve a variety of subject specialties and expertise (Burbridge, 2017; Müller & Sixsmith, 2008; Novitzky et al., 2015; Schuurman et al., 2015; Yazdizadeh & Tavasoli, 2016). Although there is a

significant body of information related to ethical approaches and well-established codes of conduct for different professional bodies (e.g., BPS 2018, UKRI) to guide research, we argue that it can be difficult to draw this information together, extract the key principles, and then apply them when guiding the set-up and running of an emerging living lab.

In England, Coventry University has sponsored an innovative and ambitious initiative, the Data Driven Research and Innovation (DDRI) Programme, as an emerging living lab involving close collaboration between university partners, residential facilities, and commercial partners. The programme aims to use data-driven analytics and insights to learn from and support residential provision for older adults, with a focus on future innovation to support healthy and independent living. This study focuses on two of the residential environments currently involved in DDRI. The first residence, Setting A, offers day care, long-term residential care, and short-term respite care for older people, and it specializes in support for people living with dementia. The second residence, Setting B, offers an independent living environment for adults over 55 years, with extra care support available for those who need it.

A number of living lab projects have been developed and launched within these two living environments. For example, a study entitled "Applied Sleep Interventions for Elderly Residents in a Care Home Setting" has explored ways to improve sleep and provide innovative ways of responding to night-time waking in Setting A. A second study, entitled "Innovation for Dementia Care: Evaluation of Digital Health and Wellbeing Apps in 'Real-Life' Living Labs" has explored the potential for digital innovations to improve health and wellbeing for frail older adults, including people living with dementia in both Settings A and B. To date, three 12-month projects and eight 3-year PhD studentships have been developed in conjunction with these settings.

This study forms part of an overarching project that recruited multiple stakeholders, including researchers, subject experts, and management, staff, residents, and families, from Settings A and B, to explore their experiences, perceptions, and concerns related to the set-up and implementation of living lab initiatives involving older adults. Here, we report specifically on the views of residents at Settings A and B as potential participants in living lab initiatives as well as family members of representative residents.

Literature Review

The relevant literature considers some of the challenges associated with engaging older adults in living labs. Although many of the challenges are common to other types of research with older adults, a number of specific ethical challenges have been identified in relation to the management and implementation of living lab projects (Habibipour, 2018; Sainz, 2012). These include how data protection and protection of privacy between studies is maintained (Sainz, 2012; van Wynsberghe & Robbins, 2014); how informed consent is established at the beginning of any living lab research initiative, and renewed during and between projects (Pino et al., 2014; Sainz, 2012); how user participation and withdrawal are managed, particularly where the living lab is a residential space (Georges et al., 2016; Habibipour et al., 2017a; Habibipour et al., 2017b); appropriate mechanisms for thanking and encouraging participation (Buitendag et al., 2012; Dutilleul et al., 2010; Georges et al., 2016); and ownership of any intellectual property (Draetta & Labarthe, 2010; Sharp & Salter, 2017; van Geenhuizen, 2014) that emerges from the living lab due to the involvement of participants in co-creation and developmental activity (Nyström et al., 2014; Ståhlbröst & Bergvall-Kåreborn, 2013).

The involvement in living labs of older adults, and potentially adults with reducing cognitive and physical capacity, poses additional challenges. These challenges are not specific to living labs necessarily, but they need to be negotiated and managed in establishing a living lab and include fluctuating capacity or loss of capacity to provide informed consent, and they may require the involvement of third-parties, such as children and carers of participants as decision makers and consultees (Novitzky et al., 2015; Panek et al., 2007; Pino et al., 2014; Sanchez et al., 2017). The approach to academic research in a living lab context will require formal ethical review and approval, but commercial development work may not. There is clear guidance related to research involving vulnerable adults from specific professional bodies that guides conduct, the development of research protocols, and applications for ethical approval (Bollig et al., 2015; BPS, 2009; NSW, 2015; Walsh, 2009). We would argue, however, that the issues brought together in living labs are complex and multidisciplinary due to the range of disciplines involved and the potential involvement of commercial (as opposed to research) organizations. Navigating the range of information available and route to ethical approval

involving potentially both university ethics committees as well as national organizations (e.g., NHS/Health Research Authority Social Care Research Ethics Committee in the UK) continues to be complex.

User engagement and motivation to participate in research and development are critical to develop sustainable living labs (van Geenhuizen, 2018). The involvement of end users as participants and/or as partners of the living lab initiative may ultimately increase the user acceptance of new products, services, or processes, and hence reduce the failure rate in the market (Dell'Era & Landoni, 2014; Habibipour et al., 2017b). Projects may seek different levels of user engagement, from users as leading co-creators, to users as passive subjects (i.e., involved in testing /evaluating living lab products and/or services) (Almirall et al., 2012; van Geenhuizen, 2014). Engaging users throughout the lifetime of a project or through a sequence of projects can be challenging. Interest, motivation, and expectations can change over time, which can lead to drop out (Habibipour & Bergvall-Kåreborn, 2016; Habibipour et al., 2017a; Habibipour et al., 2017b).

The intrinsic and extrinsic motivations of users are key drivers to open innovation research activities (Habibipour & Bergvall-Kåreborn, 2016, Ståhlbröst & Bergvall-Kåreborn, 2011). Motivation can be triggered intrinsically (i.e., without external incentives) such as due to the desire to feel competent and self-determined, or extrinsically (i.e., activated by external factors), driven for example by financial compensation or the recognition by others (Chasanidou & Karahasanovic, 2016; Georges et al., 2016; Habibipour, 2018; Ståhlbröst & Bergvall-Kåreborn, 2011, 2013). Ståhlbröst and Bergvall-Kåreborn (2011, 2013) explored the motivation of different innovation communities. They found that intrinsic motivations such as knowledge seeking (learning something new), stimulating curiosity, and being entertained, as well as testing innovative products and services that are new to the user are the most important motivators for participation. These motivators have been reinforced by other research (Baccarne et al., 2013; Lievens et al., 2014) with key intrinsic motivators for taking part in living lab research identified as personal interest (i.e., connecting with the existing interest domain of the user); contribution (i.e., the ability to participate and to contribute actively to a certain problem, and to offer possible solutions); and curiosity (i.e., being keen to find out new things, having a curious personality). Learning something new and gaining additional knowledge about new technologies and products are especially relevant for long-term engagement (Lievens et al., 2014).

The current research on motivation and engagement in living lab projects and initiatives has not specifically involved older people as participants of the living lab activities. It is argued that, with an ageing demographic, insights from older adults themselves are critical.

Sustaining participation and reducing drop-out is important to delivery timescales, cost efficiency, quality assurance, and the trust and motivation levels of participants and stakeholders in living lab projects (Habibipour & Bergvall-Kåreborn, 2016; Habibipour et al., 2017a). Factors such as a lack of perceived added value of the innovation, the extent to which the innovation satisfies the user needs, and smooth setup and running of projects play a role in drop-out rates (Georges et al., 2016). Influential factors on drop-out behaviour can be classified by adopting a socio-technical approach (Habibipour et al., 2017a). Impact has been seen at the macro, meso, and micro levels (Habibipour et al., 2018), influencing the field test process for projects as well as for the living lab as a collaborative environment. The literature suggests that, to achieve a sustainable environment, living labs need to build mutual trust and identify a set of shared objectives with all stakeholders involved (Dutilleul et al., 2010; Gualandi & Leonardi, 2018; Habibipour et al., 2018; Kröse et al., 2012; Nyström et al., 2014; van Geenhuizen, 2018). Multiple perspectives can bring value to partners in an integrative way and contribute to the living lab innovation process and outcome (Habibipour et al., 2017b; Pino et al., 2014; Ståhlbröst, 2012). It is critical, therefore, that stakeholders' needs and expectations are considered throughout the living lab project development (Dutilleul et al., 2010).

The engagement and care for older users/participants in a living lab is critical. Although the importance is recognized in the literature outlined above, there is little direct guidance on how to establish a living lab initiative that is informed by the users/participants themselves. In order to build a collaboration and shared vision for the emerging DDRI/living lab, this study provides a voice for older adults. Specifically, it aims to explore their views with respect to their participation in, and motivation to take part in, living lab research projects as the environment they live in becomes an emerging living lab.

Method

A qualitative research approach was applied for the data collection and analysis (Blaikie, 2009; Ritchie et al., 2014). The study received ethical approval from Coventry University Research Ethics Committee (P59886). A

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letter of support was provided by the residential organizations (i.e., Setting A and B). The principles of the British Psychological Society Code of Ethics and Conduct (BPS 2018) and UK Research Integrity Office's Code of Practice for Research (UKRIO) guided the research.

Research participants

The eight participants that took part were recruited from the two residential settings (Settings A and B). In Setting A, participants were recruited with the support of the staff team, who facilitated the identification of interested residents. In Setting B, flyers were distributed to advertise the study, and coffee morning events were organized at which the lead researcher gave an overview of the planned research to residents.

Six residents took part (5 female, 1 male); the average age was 79.5 years (range 56 to 90 years). Two participants lived in Setting A, whereas the other four had been living in independent apartments in Setting B for an average period of 17 months. None of the participants had a cognitive impairment diagnosed, and all were able to provide informed consent.

The views of relatives of residents should also be considered in the design of living lab studies, as often they are actively involved in the decisions related to the living environment or participation in a research study, and they may act as a consultee advising on their family member's wishes and feelings if a potential participant is unable to provide informed consent for themselves. Two family members agreed to take part in the research. Their parents, diagnosed with cognitive impairments, were not directly engaged in this study but lived in Setting A. A summary of participants is provided in Table 1 below.

Data collection and procedure

Semi-structured interviews (Yeo et al., 2014) were undertaken at Settings A and B. A concept-driven interview guideline was developed based on the study objectives and key themes raised by the literature review, but the interviews were relatively open to allow exploration of issues raised by the researchers. Questions were related to the following topics:

- what participants would want to know to consider participation in a research project
- views and concerns about participation based on exemplar DDRI/living lab projects
- exploring individual motivation to participate
- discussion of research design and ethical concerns (e.g., the design of participant briefing information, informed consent and data protection)
- the involvement of wider family members and support network

Table 1. Participant demographics

#	Role	Gender	Setting	Duration in Setting
RE1	Resident, age 56	Female	A	4 months
RE2	Resident, age 90	Female	A	12 months
RE3	Resident, age 88	Female	B	16 months
RE4	Resident, age 87	Male	B	10 months
RE5	Resident, age 84	Female	B	18 months
RE6	Resident, age 72	Female	B	24 months
FM1	Family member: mother and father live in Setting A; mother has been diagnosed with dementia	Male	A	12 months
FM2	Family member: father lives in Setting A and has been diagnosed with Parkinson's	Male	A	5 months

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The interviews were audio-recorded and transcribed verbatim. Overall, the average interview length was an hour. Participants were allowed to take breaks as requested.

Data analysis

Interview transcripts were saved, coded, and analyzed using NVivo (v.11 Plus for Windows, QSR International). An NVivo project (entitled "DDRI-Driven Research and Innovation") was created to contain the data sources, the selected literature articles, and the memo journal keeping track of all activities and decision-making points agreed throughout the development of the research (Bazeley, 2007). Qualitative content analysis (QCA) was applied in NVivo and the concept-driven coding frame built to code and analyze the raw material (Schreier, 2012). This analysis reflected the themes within the interview schedule and therefore the data collected (Saldana, 2012; Schreier, 2012). Within the NVivo project, a tree-node structure was created, with the parent-nodes (i.e., high-level categories) reflecting the relevant themes of the research. A number of child-nodes (i.e., the subcategories) specified each parent node. Figure 1 provides an overview of the coding frame used.

An intra-coder reliability test was run. As suggested by Schreier (2012), the proposed coding frame was tested twice, the second time after 14 days. The K-coefficient was .92 (i.e., "excellent agreement", being ≥0.75) and, therefore, the coding frame was consolidated (Boyatzis, 1998). All eight interviews were coded using the proposed coding frame. The segmentation strategy used as coding unit was the "meaning unit" (that is, any portion of text, regardless of length, to which it was believed a code may apply) (Coffey & Atkinson, 1996; Grbich, 2013; Saldana, 2012). To do so, all selected quotations coded into the coding frame categories were analyzed and commented upon in the findings. To gain a full understanding of the codified data, we made use of the different NVivo tools to run statistics and make data inferences. For example, the "word cloud" in Figure 2 highlights recurring words meaningful to the participants.

Name	Sources	References
LL Ethical issues	6	45
Opt-out	5	10
Paperwork and consent	5	19
Involving Family	5	16
LL_DDRI projects	8	161
Perceived needs	6	21
User Intrinsic & Extrinsic moti	6	23
Expectations set	6	27
Involvement in research	8	35
General views on LL projects	8	33
Engaging with older adults (C	7	22

Figure 1. Concept-driven coding frame used to categorize the study data

Data reliability and validity

To ensure data reliability and traceability of key-decision and development points, the NVivo project was used as a social platform where all activities could be monitored in a systematic and transparent way between project researchers. To ensure validity, the findings were reviewed and validated by key informants (i.e., the stakeholders involved in the DDRI Programme).

Findings

Here, the results have been brought together from the resident and family member participants and organized under the main themes emerging from the interviews.

Interest and participation needs

Participants, perhaps unsurprisingly, having agreed to take part in this study, were interested in research participation more broadly. Their responses to exemplar DDRI/living lab projects were broadly positive.

Figure 2. Word Cloud based on participant quotations (produced in NVivo)

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> *"This sounds interesting."* [RE1]

> *"Well, I think that's a brilliant idea."* [RE3]

> *"I'd very much welcome something like that."* [RE4]

Participants (particularly in Setting B) were drawn to projects that they perceived as offered a benefit to their health or to the health of another. For example, a project regarding sleep interventions raised particular interest in both settings, as it was recognized as an issue affecting many older adults.

> *"I think that's a really good idea, because of the thing with dementia is that your sleep patterns are all over the place, especially when it goes further down the line."* [FM1]

Queries were raised in relation to the potential side effects of a project involving dietary supplements including dosage and impact on food sensitivities. This questioning suggesting a willingness to interrogate the nature and focus of projects.

> *"This is another one that's right in my area of concern. I notice that, in your project, you've got separate ideas, like the milky drink – but I'm sensitive to milk and any dairy, cheese, or anything of that sort, so that rules that out for me, but I get the tryptophan from bananas and dates, dried dates. You know, I got a lot of faith in a nutrition book that I've got down here."* [RE4]

A project focused on measurement of bodily hydration levels led to a discussion on wearable technology, which was of interest to the participants. In the discussion of the individual projects, the residents provided examples from their personal experience, which highlighted the features of the project descriptions that were drawing their interest and the importance of the participants perceiving value in taking part.

> *"I recognize the importance of hydration, and my general health dictates that I do have a good intake of water […] I've got severe heart problems and hydration is quite serious for me because, if I have too much fluid, it affects the heart working properly […] but research into it is wonderful."* [RE3]

Study design and potential ethical challenges

Interviewees highlighted the importance of their needs and capabilities being considered in the design and delivery of living lab studies, including the pace of the research activity as well as the appropriate design of the materials used. One resident provided guidance on how to respond to some individual needs:

> *"You see, there are people with slight irritability problems, [they] get het up [agitated] very quickly – the sight of a piece of paper that they have to listen to and do anything with, it is beyond them. Apart from that, don't put any pressure on them. You know, it's how much they can cope with, and you don't know whether it's because of their underlying illness or not – you just accept them as they are, and then just work around them. […] You know, refer back to what you did, and if somebody has a better feeling, than they might do it anyway."* [RE4]

Family members were also very aware of their parents' specific communication and interaction needs, for example, the need to time an activity appropriately, repeat any questions as required, and consider how questions are phrased.

> *"…it would be good because I know how Mum communicates […] by her pointing, so even without saying anything that's communicating. […] The only thing that I think that would be difficult is if you were to spend an extended period of time with her to get her to do one single thing. Because of her concentration levels, she'd get tired very quickly. So, it should be a gently, gently approach, really."* [FM1]

Mechanisms for sharing information and gaining consent were discussed during the interviews. The family members had relatives with dementia that may have no capacity to consent or this capacity may fluctuate. It was recognized that this was not necessarily a barrier to participation (depending on the nature of the research and approvals in place). However, participants did recognize that both physical and cognitive capability may change or deteriorate as the research proceeds and that the researcher would need to respond appropriately.

> *"That's part of the thing – if this is no longer suitable for my Dad's condition or somebody else's condition, we just need to step outside the trial, please."* [FM2]

Involving older adults in a living lab, and potentially adults living with physical or mental conditions, requires consideration of potential mechanisms for information provision and processes for consent. A well-designed and inclusive information sheet is important, and the

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involvement of family or others as consultees may be required. Information about the DDRI projects was circulated in the two residential settings by means of project information sheets. Colour images and short paragraphs of text in a large, sans-serif font (Arial 14) were used to describe the different active projects and engage resident interest. This approach was regarded positively. When developing information, participants highlighted the need to take into account individual needs:

> *"Sight and hearing are important. We all look normal enough, but everyone's got some kind of underlying problem. For the people who are partly blind or blind, it could be read out to them. You would have here a few with sight problems."* [RE5]

The involvement of third parties in the process of consent to participate in a study (as consultee) was also discussed. Involving the family, or a "carer network" is well accepted by all residents, as it is something that is discussed as part of the care they receive.

> *"Well, I mean, if you as the researcher think that the person is no longer quite capable of doing it, then I think that's reasonable [to involve the family]."* [RE6]

In the context of research, it was recognized that participant wishes and attitudes should be well understood by the family, as the research may be beyond the boundaries of previous discussions residents had had with their families.

> *"Family or carers then need to know what the [person's] attitude was in relation to research."* [FM2]

Motivational requirements

Questions probed the factors that motivated participants to take part in the research. It was found that intrinsic motivation was driven by the subject of the research and whether it was felt to relate to a participant's own health and would satisfy their interests, and the perceived value of the study. The participants commented that supporting research and the "general good" was important to them, either because they believe in what the research is aiming to achieve, or due to their personal and educational background.

> *"Well, if they were told that, by doing research, that they were likely to get better, have better sleep, they would – should – be taking part. And, even if they didn't, I mean, it would help somebody somewhere."* [RE5]

> *"I know Mum wouldn't have problem at all [taking part in the research] if she knew she could help someone or something. She'd do it – she's been involved in various medical studies, I think, many years ago."* [FM1]

The resident participants also indicated that they were keen to be engaged in something challenging and mentally stimulating:

> *"I like to get involved with these sorts of things because I think it keeps my brain working. To be honest with you, it's just like if you just sat here in this flat and did nothing. I couldn't do that – I have got to be doing something, and I say it I don't mean physically, I mean mentally!"* [RE3]

> *"But then it depends on the background of the person, you know they wouldn't normally, well, they've just never heard of it. I think that's for your educational background and what sort of research."* [RE6]

Other factors affecting motivation included the perception of research. In more than one interview, it was highlighted that the word "research" seemed to convey a negative connotation and consequently led to a feeling of distance from the issue.

> *"I feel that as soon as you say research, they'll say 'Oh no – I'm not interested, thank you.' I think so because they think of researchers are really going inside you."* [RE2]

Reflections suggested that, during later life (e.g., living in senior living settings), participants may lack energy and enthusiasm for engagement.

> *"I can only tell you the impression I get from talking with people here. I feel that quite a lot of people, they are not really interested. They got to the stage in life where they just really don't want to be bothered."* [RE3]

Personal beliefs and perceptions may also deter some from participating.

> *"Getting involved with things like these, I wouldn't do it, not knowing your background, knowing where you came from, that sort of thing. I mean, I wouldn't do it to anybody who just came to the door and asked me to do it."* [RE1]

Whether to compensate or pay research participants raises much debate and potential ethical questions. Payments can be to reimburse expenses, to compensate for time, or as a gesture of appreciation for participation. When prompted about the topic, both residents and family members confirmed that participation should happen without the need for rewards.

> *"We should all do our bit and not expect a reward." [RE5]*

> *"I think if you're interested, you do it, just do it. I mean, I can't see why we need to have a reward."* [RE2]

> *"No. No rewards. That drives the wrong behaviour, doesn't it?"* [FM2]

However, residents indicated that they would like acknowledgement, and to know about the impact of the input they made, or potential future impact in society. They did not necessarily expect a personal thank you, but they expected to receive information about the outcomes the project had achieved and next steps.

> *"You know, having participated in that little bit of research, it obviously links into something else, and it could be nice if you can hear about it and think: 'Well, I feel quite proud of that, because I helped'."* [RE3]

The same view was shared by the family members.

> *"It would be nice to get the outcome, be it in the form of an email, a general email to everyone, and what the contribution was and how it's resulted."* [FM2]

Discussion and Conclusions

This qualitative, exploratory study forms part of a larger initiative, the DDRI programme, sponsored by Coventry University. It involves close collaboration with university and sector partners in their respective fields and residential facilities. Over a 12-month period, pilot research projects were launched and implemented in the two partner residential settings, and with different stakeholders engaged. The literature highlights some recognized challenges for living lab research. These include user engagement and motivation, managing the needs and expectations of multiple stakeholders, and some ethical issues. This study provided an opportunity to explore some of those issues in the context of the experiences and views of living lab participants.

The study was undertaken at the outset of the DDRI programme and was prospective, asking residents to imagine – based on specific exemplar projects – how they would feel about participation, and what would motivate them to take part. The study enabled exploration of some critical ethical concerns for an emerging living lab involving older adults and adults living with physical and cognitive impairments. These included the nature of participation in living lab research initiatives, the use of motivators/incentives, and the involvement of family in the decision making to take part.

The findings indicated that residents were interested to take part in research activities, particularly in those studies that they could directly identify with or where they could see clear value to others from their participation. The research was introduced into the participants' living environment while they were living there, rather than being a feature of the environment when they moved in. The residents and family members, despite recognizing some important elements to consider during research design, were not concerned about research being undertaken in this way and were broadly positive about the initiative.

Participants were particularly motivated to engage with research when the topics were close to their current health needs or interests. This leveraged their intrinsic motivation to participate. This is in line with research elsewhere on living lab user motivation (e.g., Habibipour et al., 2018; Lievens et al., 2014; Ståhlbröst & Bergvall-Kåreborn, 2011, 2013) that highlights the importance of "nurturing the users'" personal interests (specifically when the research topics address health issues), and the value of research providing a stimulating and engaging activity and enabling users/participants to contribute to finding solutions to their problems. The findings here show that the motivation to participate seems to be closely linked to the idea that being involved in health-related projects might bring benefits, not only at personal level but especially at a wider/community level. Supporting the research and the value "for the general good" were important. The rewards that older adult participants may seek are not monetary, but rather a "formal" acknowledgement of what they contributed. As such, they expressed the importance of being informed about results and future research development and outcomes (e.g., Habibipour et al., 2018).

Participants did raise some concerns and highlighted some issues researchers should pay attention to during their research design and implementation. For example, researchers should be aware of the potential negative connotation of the word "research" to older people. Of interest were possible alternative descriptions to define and promote living lab "research" projects, including "adult caring research" or more user-friendly phrases, such as "We want your views". Feedback was also given on the design of studies, information sheets, and communication approaches. These findings are being compiled into a set of recommendations that will continue to develop through new DDRI projects.

The interviews included some consideration of capacity to consent. The literature introduces the concepts of "fluctuating consent", "process consent", or "rolling consent" (Dewing, 2007; Novitzky et al., 2015; Stirman, 2018) to ensure ongoing consent and verify willing participation. The concept of rolling consent, for example, covers the need to repeatedly provide information and ask for consent at various stages of the research, ensuring from the participants' words (and nuances of speech) that they truly understand what they are consenting to, and communicating that they can drop out at any point (Novitzky et al., 2015). When establishing a living lab with older adults, and one involving adults lacking capacity to consent, there is a need for careful training of researchers not only in informed consent processes but also in terms of recruitment and management of related family and the wider support network. The principle of "do no harm" is key, and researcher knowledge, judgement, and integrity are important to ensure research participation is reviewed appropriately. This is an element of training that is required particularly for PhD researchers as well as more experienced researchers unfamiliar in working in this context. Collaboration and support from care staff within the settings also plays an important role.

Sustaining participation of users and wider stakeholders in a living lab is critical (Habibipour & Bergvall-Kåreborn, 2016; Habibipour et al., 2017a). Living lab projects involve medium- and long-term collaborations with research participants. We argue that it is vital to maintain the ongoing interest and cooperation of research participants, family, and other stakeholders as well as managing their expectations for successful research initiatives. This study offers the unique perspective of residents (and family members) who have become involved in a newly emerging living lab within their existing living environment.

As a first step to developing a culture of successful collaborative research within a living lab, this study has demonstrated open discussion with residents and their families that should continue to guide processes and research design as the living lab initiative continues. The findings of this study have gone on to inform co-design activity with wider groups of stakeholders at Settings A and B. As part of our collective approach, co-creation workshops were employed to develop a shared understanding of the DDRI concept and to develop and agree some initial guiding principles for researching and working together in this context.

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Urban Living Labs: Towards an Integrated Understanding of their Key Components

Diana Chronéer, Anna Ståhlbröst, and Abdolrasoul Habibipour

> *"Living in cities is an art, and we need the vocabulary of art, of style, to describe the peculiar relationship between man and material that exists in the continual creative play of urban living. The city as we imagine it, then, soft city of illusion, myth, aspiration, and nightmare, is as real, maybe more real, than the hard city one can locate on maps in statistics, in monographs on urban sociology and demography and architecture."*
>
> Jonathan Raban
> Travel writer, critic, and novelist

In today's ongoing urbanization and escalating climate change, there is an increasing demand on cities to be innovative and inclusive to handle these emerging issues. As an answer to these challenges, and in order to generate and adopt sustainable innovations and nature-based solutions in the urban areas, the concept of urban living labs has emerged. However, to date, there is confusion concerning the concept of the urban living lab and its key components. Some interpret the urban living lab as an approach, others as a single project, and some as a specific place – and some just do not know. In order to unravel this complexity and better understand this concept, we sought to identify the key components of an urban living lab by discussing the perspective of city representatives in the context of an urban living lab project. To achieve this goal, we reviewed previous literature on this topic and carried out two workshops with city representatives, followed by an open-ended questionnaire. In this article, we identify and discuss seven key components of an urban living lab: governance and management structure; financing models; urban context; nature-based solutions; partners and users (including citizens); approach; and ICT and infrastructure. We also offer an empirically derived definition of the urban living lab concept.

Introduction

Nowadays, cities are facing increasing urban complexity and grand societal challenges. Hence, there is a growing trend to make urban areas more adaptable to the needs of their citizens by preventing social problems as well as viewing the cities as a vehicle for innovation in urban planning processes (Juujärvi & Pesso, 2013; Scholl & Kemp, 2016). To meet these challenges, decision makers and other relevant stakeholders aim to develop the city as a laboratory to generate innovative solutions (Juujärvi & Pesso, 2013); an approach that is in line with the living lab concept.

Living labs are generally known as a way to manage innovation processes in an open, inclusive, and collaborative approach in which the innovations are developed by engaging various stakeholders including public organizations, private sectors, universities, and citizens (Bergvall-Kåreborn et al., 2009; Ståhlbröst, 2008). So, it is important to include external sources of knowledge and ideas within the innovation process, which is consistent with the notion of "open innovation", a term that was first coined by Chesbrough (2003) and is at the core of the living lab concept. Also, living labs are based on specific methodologies and tools, and they are implemented through specific innovation projects and community-building activities (Schaffers & Turkama, 2012). But, despite attempts in the literature to clarify the concept (e.g., Almirall et al., 2012; Leminen, 2015), living lab practices and theories are still under-researched (Schuurman, 2015).

As cities becomes an arena for innovation, the need grows for new approaches for citizen engagement, urban development, and new collaboration models (Evans

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& Karvonen, 2011). As an answer to this growing need, the concept of the urban living lab has emerged. In the urban living lab, the whole city is viewed as a living laboratory where citizens and other stakeholders are actively involved in the process of designing, developing, implementing, testing, and evaluating an innovation (Veeckman & van der Graaf, 2015). Accordingly, the aim of an urban living lab is to generate and adopt sustainable innovations and solutions in the urban system in light of the urban sustainability transition (Steen & van Bueren, 2017). Despite this, there are few studies about the concept of the urban living lab (Baccarne, Mechant, Schuurman, Colpaert, & De Marez, 2014; Steen & van Bueren, 2017) and, as previous studies show (Steen & van Bueren, 2017; Voytenko et al., 2016), there is no general scientific agreement on what an urban living lab is and what constitutes the required components of an urban living lab. One plausible explanation for this is that most of the studies that have presented a definition, a framework, or a model for an urban living lab without focusing on its main characteristics. As a result, the concept becomes a mixture of components, activities, aims, principles, and actions that should be considered in an urban living lab (e.g., Juujärvi & Pesso, 2013; Scholl & Kemp, 2016; Steen & van Bueren, 2017). This, in turn, leads to greater complexity and vagueness around the urban living lab concept. Therefore, we argue that the literature requires a comprehensive clarification of the concept if we are to understand and study the effects of an urban living lab and gain benefits from its implementation in cities around the globe. As a first step towards this clarification, we need to identify what constitutes an urban living lab, what are its key components, and how we can understand them.

Considering the key components of a "generic" or "traditional" living lab, five of them are well-known: 1) ICT and infrastructure; 2) management; 3) partners and users; 4) research; and 5) approach (Bergvall-Kåreborn et al., 2009; Ståhlbröst, 2008). However, given the early stages of the development of urban living labs (Bulkeley et al., 2016), and despite the fact that some studies have presented different elements, characteristics, and features of an urban living lab (Steen & van Bueren, 2017; Voytenko et al., 2016), to our knowledge, there are still no studies exploring the five key components of a traditional living lab as outlined by Bergvall-Kåreborn and colleagues (2009) and Ståhlbröst (2008) when it comes to the urban context. Therefore, this article explores the differences (if any) between the traditional living lab key components and those in an urban context. In contrast to more "traditional" living lab approaches, urban living labs have a complexity built into them consisting of aspects such as politics, power of decision making, financing models, etc., which remains unaccounted for. Moreover, several questions remain unanswered, such as: What is the main objective of an urban living lab? What challenges does it aim to solve? What governance model is suitable for an urban living lab? What approaches should be adopted in an urban living lab? Who should be engaged in the innovation process and how?

Hence, in this study, we aim to define and discuss the key components of an urban living lab, which will further our understanding of the concept. The research has been carried out in an EU funded project called UnaLab (No. 730052-2), which incorporates ten different cities in Europe aiming to implement urban living labs to support the development of nature-based solutions in cities. The International Union for Conservation of Nature (IUCN) defines nature-based solutions as: "… actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g., climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits" (see Frantzeskaki et al., 2017). To support our research, it is important to understand how previous studies have grappled with the concept of an urban living lab; to include the perspective of cities and how they have interpreted the key components; as well to move forward our understanding of the concept of the urban living lab as a whole. In so doing, we first review previous literature on this topic and then present the results of two workshops with the city representatives, followed by an open-ended questionnaire.

The remainder of this article is structured as follows: the next section presents a literature review on the topic, which is followed by the overall methodology of the study. After that, the results of the two workshops as well as the questionnaire are presented. Then, we discuss the findings and offer some concluding remarks.

Literature Review

When looking at the concept of living labs, we can discern that there is a growing trend to involve citizens (and other stakeholders) in different city development projects with the aim to create urban areas that are

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more adaptable to different citizens' needs (cf. Baccarne, Mechant, Schuurman, Colpaert, & De Marez, 2014). Today, urban areas are seen by different stakeholders (e.g., city planners, universities, and technology companies) as natural innovation arenas to develop ideas in living labs settings (Juujärvi & Pesso, 2013). In comparison with a generic living lab, which focuses on facilitating interaction between end users and private actors, urban living labs are more oriented toward "urban" or "civic" innovation (Baccarne, Schuurman, Mechant, & De Marez, 2014). Baccarne and colleagues (2014) also highlight that urban living labs are often supervised by (or have a close relation with) the local government and have a strong focus on social value creation and civic engagement and on non-commercial activities.

However, the distinction between the terms "living lab" and "urban living lab" is not clear in the literature (Steen & van Bueren, 2017). For instance, Schliwa (2013) states that "sustainable living labs" targeting generation of knowledge within a small-scale real-life laboratory are similar to urban living labs but with a focus on the implementation of socio-technical innovations on a larger urban territory targeting knowledge generation as well as application. Thus, the urban living lab concept expands its activities on a broader urban territory, which also affects the way that key stakeholders are engaged (Schliwa, 2013). Also, an urban living lab has a distinct focus on knowledge and learning as a mean through which such interventions can be successfully achieved (Bulkeley et al., 2017).

Looking at the definition of an urban living lab, Steen and van Bueren (2017) state that researchers often adopt existing definitions related to the concept of "living lab", such as the one used by the European Network of Living Labs (ENoLL, 2016): "Living labs are defined as user-centered, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" (Steen & Van Bueren, 2017). But, Steen and van Bueren (2017) highlight that the term "urban living lab" often refers to a variety of local experimental projects of a participatory nature, meaning it is often used interchangeably with the terms "testing ground", "hatchery", "incubator", "maker space", "testbed", "hub", "city laboratory", "urban lab", or "field lab".

With the goal of operationalizing the definition of urban living labs, Steen and van Bueren (2017) assessed 90 sustainable urban innovation projects in the city of Amsterdam. Based on their research, they identified four key characteristics of an urban living lab, namely: aim, activities, participants, and context. Their analysis was based on sustainable urban innovation projects in general, not urban living labs in particular. Hence, Steen and Bueren (2017) highlight that their assessment shows that the majority of the projects, as living labs, did not include one or more of the defining elements of a living lab. They also argued that excluding one or some of these basic components of the living labs might lead to disappointing performance in the whole innovation development process. According to their study, the aims of urban living labs are innovation and formal learning. The main activities are innovation development, co-creation, and iteration of the design and development process by considering feedback from the previous steps. When it comes to participants, public and private sectors, citizens, and knowledge, institutions are of vital importance as is context, which is always a real-life everyday use context. With respect to the characteristics of an urban living lab, Voytenko and colleagues (2016) presented five of them: 1) geographical embeddedness, 2) experimentation and learning, 3) participation and user involvement, 4) leadership and ownership, and 5) evaluation and refinement.

Further, Juujärvi and Pesso (2013) have identified three main levels of engagement in the process of urban living labs. In the first type, the urban context can act as a technology-assisted research environment by collecting as much citizen feedback as possible by using different sensors and Internet of Things (IoT) deployments. In the second type, citizens can also be co-creators who contribute to designing and developing local services and urban artefacts (e.g., communal yards, day-care services). The third type of urban living lab represents a new kind of urban planning that uses novel processes and tools that are developed by actively engaging citizens. In this third type, the objective is to plan procedures and facilitate vision planning, which will lead to increased mutual learning of various stakeholders, including citizens.

Veeckman and van der Graaf (2015) identified three main benefits of viewing the city as an urban living lab: 1) it facilitates citizen participation and collaboration; 2) it facilitates co-creation processes in the city, and 3) it empowers citizens. They also suggested that, by using different tools and techniques, citizens who do not have very high technical skills are also able to participate in the progress of their cities and can contribute to the development of different solutions that are beneficial for their city as well as their everyday urban lives.

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Steen and van Bueren (2017) identified five main innovation-related activities in urban living labs: 1) research, 2) development, 3) testing, 4) implementation, and 5) commercialization. They then classified 90 potential living lab projects in the Amsterdam region under these five themes. Their findings showed that development of an innovation is the most frequent innovation process phase in an urban living lab. Steen and van Bueren also argued that only projects that conduct development activities can be considered as a living lab project. Accordingly, in an urban living lab context, the innovation must be developed in the city by including relevant stakeholders and citizens and testing or implementing an innovation would be a complementary phase.

In another study based in the Netherlands, designed to assess the role of urban experiments for local planning processes, Scholl and Kemp (2016) conducted a case-based analysis of the city of Maastricht and identified five key characteristics of urban living labs (which they labelled as "city labs") as a distinct analytical category for looking at urban labs and urban experiments from a planning perspective. First, city labs are hybrid organizational forms purposefully positioned at the border of local administration and society. Second, city labs are places of experimental learning and are learning environments for new forms of governance. Third, city labs are multi-stakeholder settings including the local administration and focus on co-creation. Fourth, city labs use co-creation in conducting experiments. And fifth, city labs approach complex problems in a multi-disciplinary way, by drawing on knowledge from different disciplines.

Different researchers have explored, defined, and characterized urban living labs, as summarized in Table 1. All of these studies have tried to clarify the concept by understanding urban living labs from different perspectives and at different levels. In these perspectives, there is a mixture of components (e.g., activities, participants, and hybrid organization form), activities (e.g., research, development, testing, evaluation), aims (e.g., innovation, learning, empowerment of citizens), principles (e.g., co-creation, multi-stakeholder engagement, participation) and contextual factors (e.g., geographical embeddedness, technology-assisted environment, learning environment) that constitute an urban living lab, which also contribute to the concept's complexity. Accordingly, we argue that a concise definition of the key components of an urban living lab is still lacking.

Therefore, in order to better understand the key components of an urban living lab, we will discuss the five key components of generic living labs (i.e., ICT and infrastructure, management structure, partners and users, research, and approach) as outlined by Bergvall-Kåreborn and colleagues (2009) and Ståhlbröst (2008) in the light of the key components of an urban living lab by analyzing other aspects that constitute its main components.

Research Methodology

Given the need for research into the components of urban living labs, this study uses a qualitative and exploratory research approach. To reach strong results in qualitative research, it is important to stimulate interaction between research and practice and to include a variety of perspectives in the study (Kaplan & Maxwell, 2005). In this study, we were particularly interested in grasping the city representatives' understanding of an urban living lab and how they could work with a suitable framework in order to meet the cities' individual urban challenges.

The UNaLab project

This study was performed as part of the UNaLab project (730052-2), which is funded by the European Union under the Horizon 2020 research and innovation program. The UNaLab project aims to develop smarter, more inclusive, more resilient, and increasingly more sustainable societies through innovative nature-based solutions. The UNaLab partners (including 10 municipalities and members from research, business, and industry) commit to address the challenges that cities around the world are facing today, by focusing on climate and water-related issues, within an innovative and citizen-driven paradigm. UNaLab has three front-runner cities, Eindhoven, Genova, and Tampere, each with a track record of employing smart, citizen-driven solutions for sustainable development. These three front-runner cities will implement urban living lab demonstration areas within their cities. They will address identified challenges related to urban climate and water by co-creating nature-based solutions with local stakeholders and citizens using an innovative and systemic decision-support tool. The solutions then will be replicated in seven follower cities: Stavanger, Prague, Castellon, Cannes, Basaksehir, Hong Kong, and Buenos Aires plus they share experiences with observers such as the City of Guangzhou and the Brazilian Network of Smart Cities. The follower cities will therefore work in collaboration with the front-runner cities to develop nature-based solutions in a co-creation approach. In this study, we have mainly included the cities Eindhoven, Genova, Tampere, Stavanger, Prague, Castellon, Cannes, and Basaksehir because their representatives participated in the workshops.

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Table 1. Different perspectives to define an urban living lab

	Key Features of an Urban Living Lab	Key Identifiers
Types (Juujärvi & Pesso, 2013)	• A technology-assisted research environment • Co-creating with citizens • Actively engaging citizens in urban planning processes	• Milieu • Activities
Benefits (Veeckman & van der Graaf, 2015)	• Facilitating citizen participation • Facilitating co-creation processes • Empowering citizens	• Approach • Principles
Characteristics (Voytenko et al., 2016)	• Geographical embeddedness • Experimentation and learning • Participation and user involvement • Evaluation and refinement • Leadership and ownership	• Actions • Components • Contextual
Characteristics (Scholl & Kemp, 2016)	• Hybrid organizational forms • Learning environments • Multi-stakeholder settings • Co-creative experimentation • Multi-disciplinary approach	• Components • Approach • Contextual
Activities (Steen & van Bueren, 2017)	• Research • Development • Testing • Implementation • Commercialization	• Activities
Characteristics (Steen & van Bueren, 2017)	• Aim: innovation and learning • Activities: co-creation and decision power, and feedback and iteration • Participants: public, private, users, knowledge institutions • Context: real-life use context	• Activities • Components • Contextual

The UNaLab project aims to fulfil the present need to develop a framework that can support the development of an urban living lab from a different perspective and to identify and understand the key components, objectives, challenges, and characteristics of an urban living lab based on both theory and practice.

Data collection methods

In order to obtain a better understanding of urban living labs from the perspective of city representatives and to define the concept of an urban living lab, two workshops were organized in the UNaLab project, followed by an open-ended questionnaire to validate the collected data in the two workshops.

The first workshop was held in November 2017 in the front-runner city of Genova, Italy, with seven UNaLab project partners to deepen the participant's knowledge and understanding of the urban living lab concept, while at the same time gathering information on the topic and capture their perspective as the city representative by reflecting on: 1) the key components of a

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traditional living lab as outlined by Bergvall-Kåreborn and colleagues (2009) and Ståhlbröst (2008), and 2) additional components derived from the urban living lab literature: innovation, an urban context, citizens, methodologies, and the management structure. Following this approach enabled us to refine the initial list of key components and add or remove other key components that are applicable in urban living lab context. The workshop participants were asked to respond to questions such as: From your perspective, what should urban living labs achieve at the end? What is the problem or challenge they aim to solve? What is an urban context to experiment in? What is the innovation in your context? Who should be engaged in the innovation process and how? What is the management structure for the governance of an urban living lab? The first workshop involved 35 participants with representatives from both front-runner and follower cities and lasted for approximately 60 minutes. In this first workshop, general discussion around the tables was captured on post-it notes posted on the templates. At the end of the workshop, the main outcomes per each table were shared in a short debriefing by the participants.

The aim of the second workshop, carried out in November 2018 in the follower city of Basaksehir, Turkey, was to validate the results obtained in the previous workshop, as well as to exchange knowledge on urban living labs and to gain a rich picture of the current situation of the cities by reflecting on the refined key components of an urban living lab. In this workshop, we were also interested in knowing in what phase of lab development the cities were in and how to proceed with setting up and running a living lab in their own cities. Seven participants from both front-runners as well as follower cities attended the workshop and it lasted approximately 80 minutes. In this workshop, general discussions around three tables was captured on templates aiming to support the set-up of an urban living lab. At the end of the workshop, a feedback form was distributed to the participants, who reflected on the main learning outcome of the session as well as the next step of developing the urban living lab framework from their perspective.

When analyzing the results from the second workshop, confusion about the concept of urban living labs appeared, hence, an open-ended questionnaire was distributed (in December 2018) to the front-runner and following cities with the aim of gaining more insights into how the concept of the urban living lab was understood and implemented (or planned to be implemented) in the front-runner cities.

To promote stronger and more reliable results, the collected data was independently analyzed by three researchers.

Results

The first workshop: Genova, Italy

In the first workshop, seven templates were distributed between participants to discuss the initially identified key components of an urban living lab. The three templates focused on: 1) the definition and objectives of an urban living lab in general; 2) the five traditional key components of a living lab, and some additional components extracted from the literature: innovation, an urban context, citizens, methodologies, and the management structure; and 3) the reflections about the templates. In total, the main challenges with the innovative nature-based solutions were identified as involving stakeholders, increasing trust, and co-creating with the citizens.

Regarding the city stakeholders, their representatives in the workshop highlighted the importance of identifying and engaging multiple citizen groups ranging from children to the elderly, and incorporating diverse groups such as business owners, public servants, researchers, visitors to the "space", and people with disabilities.

Looking at the cities' individual urban challenges (i.e., what the cities want to accomplish), they all highlight environmental issues – on a global level as well as on a more common and local level. On a global level, climate change and developing an ecosystem were highlighted. On a more common, city level, the focus was on bringing the nature back into the city. Finally, on a more specific local level, the focus was on decreasing local climate problems, such as flooding. This finding is in accordance with what was stated in earlier research – that urban living labs are more oriented on "urban" or "civic" innovation (Baccarne, Schuurman, Mechant, & De Marez, 2014).

The potential objectives of urban living labs discussed by the city representatives were in several cases similar to the generic living lab concept (Bergvall-Kåreborn et al., 2009; Ståhlbröst, 2008), such as providing a framework for research work or for innovating, experimenting, knowledge transfer, and co-creation. However, some more urban-related aspects highlighted in the definitions were the environment where citizens participate in designing solutions, the way to co-construct the city with citizens and local authorities, a place to involve citizens to experiment ideas at, a shared long-

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term program of activities, getting people involved in creating their future, a real life innovation and experience, and focusing on the long-term scaling of an innovation.

In addition, some city representatives highlighted other specific urban-related aspects in the cities such as: covering the full spectrum of challenges facing the city; solving urban problems in an effective and sustainable way by adopting user-centred design; adding visibility to nature-based solutions; improving the livability, sustainability, and social-hydrological resilience of the urban area; including citizens in decision making regarding issues related to their living environment; raising awareness of the citizens; and creating a strong ecosystem and joint value system model.

The most difficult components to discuss in the workshop were the potential management structure for governance of an urban living lab and its long-term financing. Almost all groups identified these as the most difficult questions to answer. Here, the city representatives discussed issues such as how to finance an urban living lab and a nature-based solution on a long-term basis, who should be responsible for it, how should an urban living lab be managed and by whom, and whether an urban living lab should be implemented in the whole city and all its development activities as part of a citizen-engagement policy. Based on that the discussions, we conclude that the concept of the urban living lab is complex because it is implemented in a city context. Other aspects mentioned by the workshop participants when they were asked to explain and elaborate on the key defining components of an urban living lab included testing new solutions, a way to co-construct the city with citizens and local authorities, an innovative governance experience in a real urban context, and a place for implementing new networks.

The second workshop: Basaksehir, Turkey

With the aim to validate the results obtained in the previous workshop and refine the core components of an urban living lab, seven templates were developed. The templates were mainly based on the previous workshop and literature related to the concept of the urban living lab, however, ICT and infrastructure and key stakeholders were also added to the previous templates based on the feedback from the previous phase.

The outcome of the second workshop resulted in a knowledge exchange between participants to obtain a rich picture of the current situation of the cities and reflecting on the key components of an urban living lab. The workshop also enabled the cities to develop their understanding of what phase of development they were in and how to proceed with setting up and running their own urban living lab. The workshop participants learnt about urban living labs through the introduction presentation as well as through their discussions into the seven key components of the urban living lab framework (i.e., the definition and objectives of an urban living lab, the innovation, the context, partners and users, approach and methodology, the management structure, and finally ICT and infrastructure).

In this second workshop, the workshop participants identified the following three templates as most challenging: 1) innovation (which is the nature-based solution in their context), 2) the ICT and infrastructure, and 3) the approach and methodology. Furthermore, some participants argued that some questions in the templates did not apply to their situation, which confirmed the lack of clarity and complex nature of the urban living lab concept. This was the feedback that we were aiming for, so that we could develop templates that will be helpful for cities when setting up their urban living labs.

At a glance, the results of the workshop showed that, in relation to the nature-based solutions (i.e., the innovation in urban living labs), some practical aspects are influential in the process of solution development. The participants highlighted a need to ask questions such as: How long does the development and experimentation of the nature-based solution take? How much does it cost? What kind of human resources are needed? Also, regarding the partners and users, the cities sought more help and support to understand what stakeholders should be involved in the process of developing nature-based solutions and in which phase. And, related to the citizens, it was suggested that the way in which citizens are affected by the nature-based solution should be taken into account in the templates, not only during the solution development and implementation process, but also after it has been completed. In respect to the ICT and infrastructure, the participants prioritized questions related to how the data, hardware, software, and networks can be put to work. Moreover, they felt that it was important to identify who is responsible for each of the components of infrastructure. As suggested by the city representatives, a clear distinction must be made between open and closed data and the way that it should be managed within an urban living lab.

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The questionnaire

After the second workshop, we sent an open-ended questionnaire to the city representatives and received nine responses: five from front-runner cities and four from follower cities.

When asked the question of "What is your view is an urban living lab?", the results showed that different cities have interpreted the concept of an urban living lab differently. Some of them have viewed the urban living lab as an approach to manage the process of developing nature-based solutions, some city representatives saw it as a test bed to experiment with the nature-based solutions, some considered it as a physical environment (e.g., a park, a housing block, or a district, or even a whole city) and some understood it as a tool that can foster the innovation and co-creation process in the city context by involving citizens and other relevant stakeholders. However, the responses also showed that some representatives were not very familiar with the concept of the urban living lab. For example, a representative from one follower city stated: "I don't have much experience in this field. I've listened in many places about the concept of the urban living lab, but my definition is an urban space for citizens to test innovation."

According to our experience and previous discussions with the city representatives, many of them could not make a clear distinction between an urban living lab and a nature-based solution at the conceptual level. For some cities, urban living labs are not necessarily for the implementation and construction of nature-based solutions; however, they consider the approach (or tool) useful to design, develop, implement, and test various types of innovation, including nature-based solutions. The responses to this question also showed that sometimes they consider urban living lab as a solution to develop a highly complex technological innovation, which might not be a solution to address challenges such as climatic and environmental challenges.

In this questionnaire, we also asked in what phase of development of a nature-based solution the front-runner and follower cities are and where do they see themselves in the process of setting up and running their own urban living lab. In so doing, the cities were asked to respond to the question of "From your perspective, have you implemented an urban living lab in your city?" The answers ranged widely: one said their urban living lab was fully implemented, two said their implementation was nearly done, one said they were planning one but had not started, one said they will not implement one, and another said they did not know. The representative who stated that their urban living lab has been fully implemented also mentioned that "it is not implemented for nature-based solutions or as part of the UNaLab. The municipality has several urban living lab initiatives regarding social issues in specific city districts. The urban living labs are financed by the municipality and also partly by the government to improve living conditions. The municipality is responsible for the urban living labs. A range of activities are used for citizen involvement: meetings, workshops, and office days for the municipal workers in the field."

One of the cities that believed they have almost implemented an urban living lab said: "The city has opened this planning phase area for R&D projects, experiments, people, and culture". From their perspective, systematic methods to run an urban living lab (e.g., vision, data management, and learning) are developed. However, they emphasized that the next steps (experimentation) are currently under ideation and planning. As another city mentioned: "Some urban living labs are already working – on other subjects. For nature-based solutions, we have existing projects in the inner city where we implement nature-based solutions. The learning part is what we want to improve. This needs more focus and organization. Finance and co-creation or other engagement of stakeholders is part of the existing project."

One of the front-runner cities that reported planning to start setting up and running their urban living lab stated that, from their perspective, an urban living lab needs a physical place to be operationalized: "The administration is thinking of finding a physical place to install the urban living lab, but it has not yet been decided how to implement it. It will probably be managed by the municipality."

One city has also emphasized that they are not going to set up an urban living lab. In response to the question of "What is the main reason why you will not implement an urban living lab?", they mentioned that they do not have enough power and influence to implement an urban living lab in their city. As they said: "We are the body in charge of developing the concept behind the city's architecture, urbanism, development, and formation. We mainly draft and coordinate documents in the following areas: strategic and spatial planning and development, public space, transport, technical matters, and landscape such as economic infrastruc-

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ture – and we can't implement projects". However, they have considered an urban living as a positive approach for the future.

In the last question, we asked them to share any other feedback or insights that may be relevant to the main aim of the questionnaire. In general, most of them found that the concept of the urban living lab was very interesting concept, and they were interested in knowing more about it. Some city representatives asked for more concrete examples, step-by-step guidelines, and precise instructions in order to gain knowledge on how to set up and run an urban living lab in their cities. They were also seeking training sessions from living lab experts who would be able to exchange knowledge in this field.

Discussion

Through this study, we identified seven key components of an urban living lab. These components are derived from the literature and modified according to perspective of city representative in the study. The following components are highlighted:

1. Governance models including management structure, politics, and policies

2. Financing and business models

3. A physical representation that takes place in a real-life setting in the city context

4. An innovation to experiment with (in this article, usually a nature-based solution).

5. Partners and end users, including citizens, public and private actors, and academic institutions (i.e., a quadruple helix)

6. Approaches for engaging different stakeholders and collecting data

7. ICT and infrastructure such as IoT devices, sensors, and tools

Figure 1 illustrates these seven key components of an urban living lab in contrast to the five key components of a traditional living lab. In an urban living lab, less emphasis is placed on the component of research, probably due to the fact that the urban living lab activities are carried out in a city context with the aim to create better living conditions for its citizens. However, it has been emphasized that learning and knowledge sharing is a vital part of an urban living lab (Steen & van Bueren, 2017), which might imply that research could be an important component of an urban living lab, even though our study does not reflect this as clearly.

The first component of management, in a previous study (Ståhlbröst, 2008), focused on how the living lab should be managed in order to become sustainable. In the urban living lab, this component has been enriched with the aspect of governance and also politics. The result indicates that urban living lab activities must be supported by decision makers in the cities and also by politicians if they are to happen, hence, an urban living lab has a more political dimension to it than traditional living labs. The need for leadership, ownership, and management of the urban living lab has been discussed in both Juujärvi and Lund (2016) and Voytenko and co-authors (2016), who also stress the balancing act needed between steering and controlling and the urban living lab's need to be flexible and effective. These authors do not discuss the area of politics and policy making and its relevance for urban living labs and their success. For an urban living lab to be sustainable on a long-term basis, policies supporting the approach need to be implemented. One such policy could be, for instance, that all urban development projects in a city

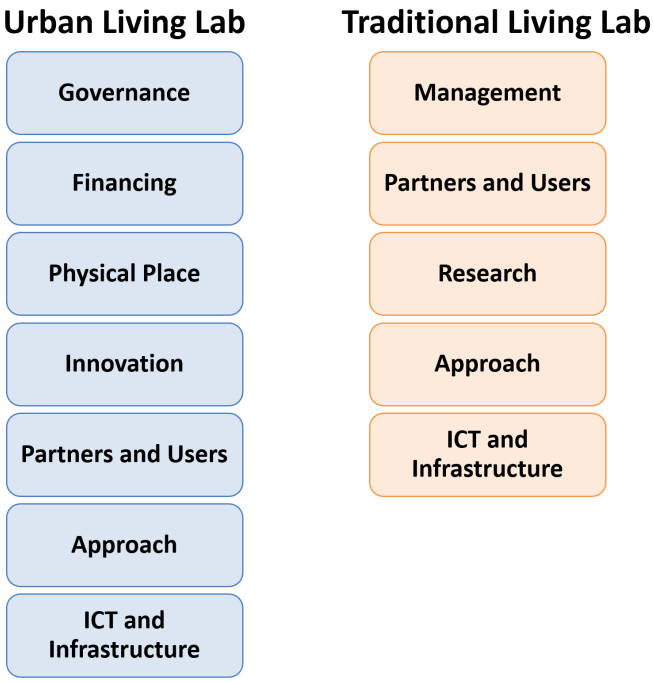

Figure 1. The key components of an urban living lab vs. a traditional living lab

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should be co-created with citizens. For this to happen, policies, governance models, and allocation of resources are of vital importance. Hence, our findings can be related to the argument by Baccarne, Schuurman, Mechant, and De Marez (2014), which states that local governments and decision makers have a strong influence. However, although they focus on social value creation and citizen engagement on non-commercial activities –those are expected outcomes of the urban living lab activities – we claim that decision makers have a prominent role in the existence of urban living labs.

This leads to the second component that differs from what previous research has identified: the financing and business model component. This can be seen as being part of the governance and management component, but based on our study, we see that financing the urban living lab and its activities is crucial to make it happen and thus it is key to its sustainability. This component has not been discussed in previous research, which can be explained by the focus on urban living labs as innovation projects (e.g., Juujärvi & Lund, 2016; Steen & van Bueren, 2017; Voytenko et al., 2016), where the financing of the project is pre-determined. In our study, the city representatives view an urban living lab as a "long-term program", an environment, and as a place. Hence, it emerges as something that needs a long-term commitment from the city, and thus there is a need to have both a financing model and well as a maintenance plan. The city representatives in this study did not highlight the business model concept as such but mentioned that finding financing, ways to engage citizens and other stakeholders, and building relationships with them, are all part of a business model and hence are needed in making an urban living lab sustainable.

One precondition in living lab activities is that they are situated in real-world contexts, not constructed laboratory settings. Thus, inherent in the concept of urban living labs is the component of physical context, or geographical embeddedness, as Voytenko colleagues (2016) refer to. This means that an urban living lab needs to have some kind of physical representation (Steen & Bueren, 2017), which is in contrast to traditional living labs, which tend to be more mobile and dynamic. This place can either be where the innovation is implemented, in this article the location of the nature-based solution, or a place where stakeholders can be invited to participate in co-creation activities, that is an urban living lab "office". The physical representation is also connected to the components of financing and governance: a physical implementation needs to be maintained over a certain period of time to create value for the citizens. Here, the physical context can be assisted by technology, as suggested by Juujärvi and Pesso (2013), but it can also be a physical representation of the urban living lab activities as in the UNaLab project with its nature-based solutions. The urban living labs in our study were bounded to a place in which experimentation and co-construction takes place. These places also need to alter their character to create an experience of nature and enhanced feeling that increases a citizen's awareness of nature and sustainability. In traditional living lab settings, innovation is not regarded as a component as such since the living lab is viewed as a milieu for innovation, in other words, the goal is to support innovation activities and engage different stakeholders in an innovation process. But in an urban context, the component of innovation can be regarded as a desired outcome from the urban living lab activities, but also as an important component of the urban living lab itself. After all, without an innovation to experiment with, co-create, or test, there would be no urban living lab activities. The innovation does not need to be decided on before the activities begin; identifying the innovation could be within the scope of citizen participation activities. Related to this component, it is important to identify what the aim of the innovation is and what value it aims to create for whom.

In respect to the component of partners and users, the specific relationship between partners and users is emphasized in the traditional living lab literature. In an urban context, a mixture of different stakeholders is highlighted: public and private sectors, research institutes, and citizens should all be engaged in urban living lab processes, meaning the lab is a multi-stakeholder setting (Schnoll & Kemp, 2016). Also, the characteristics of the citizens and their role are somewhat different in urban living labs than in traditional living labs. This means that, in an urban living lab, the citizens are involved as citizens, and not necessarily as users, given that there might not be a solution to "use" but only to experience or being affected by once the solution is in place. For instance, a nature-based solution that prevents a city from flooding has no obvious users, but is has "affectees" that no longer have a flooded city and thus their experience is affected positively. By being engaged in the co-construction of these nature-based solutions in urban areas, citizens also gain the opportunity to become actively engaged, to learn, and to thus feel responsible and also empowered to take action against situations that might have an impact on them.

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Hence, looking at the partners and users component, it includes the inherent characteristic of participation and inclusion, which can lead to empowered, enlightened, and active citizens that collaboratively wants to contribute to the sustainability of the city. Involving citizens in an urban living lab also means that the focus might shift from co-creation to co-constructing. This means that, in the cities we have studied, the focus is on constructing a nature-based solution in a specific place and thus creating an attractive space where citizens can enjoy the place. Hence, the co-construction of the place precedes the co-creation of the space.

Finally, the last components, the approach and the ICT and infrastructure, are similar in a traditional living lab and in an urban context. There is a need for a variety of methods and tools to support the urban living lab activities. Again, a multi-disciplinary approach is required (Scholl & Kemp, 2016). In relation to the ICT and infrastructure, it is of importance to clarify the responsibility of each component of the infrastructure and the distinction of open data and closed, and the way it should be managed within an urban living lab.

Conclusion

As our results have illustrated, the urban living lab concept can be understood in many different ways: it can be seen as a tool, an approach to co-construct innovations, a platform, an environment to a test bed, a long-term program, or a development model. Understanding the components above provides the basis for setting up and managing an urban living lab, but merely having the components in place will not guarantee a viable and sustainable lab. It is also important to clearly define the objective of an urban living lab and design its inherent characteristics to increase its likelihood of success.

To conclude, the results of our study enabled us to provide a unified definition for an urban living lab that includes the city representative view:

> *"An urban living lab is a local place for innovative solutions that aims to solve urban challenges and contribute to long-term sustainability by actively and openly co-constructing solutions with citizens and other stakeholders."*

Hence, the results also show that there are some differences between a traditional living lab and an urban living lab regarding some of the key components. An urban living has four specific dimensions. First, it is a long-term organization that support the process of enhancing sustainability in an urban area by having all the components organized in a viable manner. It is not merely a small innovation project carried out in a city context with citizens. Second, it is an approach through which citizens and other stakeholders should be engaged by using different methods with the objective to create value and long-term sustainability of the solution. Third, it is locally bounded to a place where local issues in the urban area can be experimented with while contributing to global challenges. Fourth, it is a political act to implement an urban living lab since the activities need to be supported by politicians and there is a need for policies to ensure sustainability. In summary, the importance of governance, ownership structure, and financing indicate that a more sustainable business model is needed for a living lab in an urban context.

This study contributes to the body of living lab literature by providing an integrated model as well as an empirically derived definition for an urban living lab in order to better understand its key components. This understanding can serve as a basis for the cities to know how to setup, govern, and manage their urban living labs and the factors influencing their innovations and development processes. The presented model will also help answer questions such as who should be engaged and how, what methods should be applied to engage citizens, who starts the process, who is responsible to run the experimentation process, and how the governance model of an urban living lab should be structured.

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Innovation Management in Living Lab Projects: The Innovatrix Framework

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Annabel Georges, and Olivier Rits

> *"The man who asks a question is a fool for a minute, the man who does not ask is a fool for life."*
>
> Confucius (551–479 BC)
> Teacher, editor, politician, and philosopher

Despite living labs being described as "orchestrators" and innovation intermediaries, there is scant literature providing concrete guidelines and tools for living lab practitioners on the topic of project-related innovation management. To address this need, we propose Innovatrix, an innovation management framework built upon existing business model and innovation management tools and frameworks and iterated based on practical experience in living lab projects. In this article, we illustrate the added value of the proposed framework through three practical case studies that lead to three propositions regarding innovation management in living lab projects. First, Innovatrix helps to scope the user involvement activities, which leads to greater efficiency and faster decision making. Second, Innovatrix forces the project owner to focus on a limited number of customer segments, which increases the speed of learning as the scarce entrepreneurial resources are dedicated to a limited number of segments. Third, Innovatrix allows practitioners to capture the iterations and pivots that were made during an innovation project, which helps to link specific outcomes with certain living lab activities.

Introduction

Living labs are complex partnerships, as they facilitate not only university–industry relationships but also relationships between large companies, SMEs, and startups, resulting in what is often referred to as public–private–people partnerships (4P's) (Westerlund & Leminen, 2011). They are mostly initiated and funded by policy makers with national or regional policy objectives in mind (Katzy, 2012) where they function as "innovation intermediaries" to overcome the gap between R&D and market introduction. Surprisingly, there is a lack of studies that indicate the effectiveness of these organizations in realizing this ambition (Ballon et al., 2018). One of the main arguments relates to the complex nature of innovation activities and the abundance of potentially influencing factors on innovation outcomes. Thus, in order to better understand their effectiveness and realize the full potential of living labs as "innovation intermediaries", there is a need for clearer reporting of living lab activities to allow benchmarking and comparing. Moreover, Leminen and Westerlund (2017) detail a variety of innovation tools available for living lab practitioners, but they also highlight the absence of structural frameworks to apply these tools. Therefore, we believe there is a need for practitioner tools specifically designed for innovation management in living labs in order to help practitioners in the selection of living lab activities and to allow more comparisons and benchmarking between different projects and living lab organizations.

Although it has been argued that opening the innovation process through the involvement of external actors in a structural process has the potential to increase the value and sustainability of an innovation's business model (Baccarne et al., 2013), there is only a limited amount of literature available that combines living labs with business models. Rits and colleagues (2015) note that the majority of the papers in this field deals with

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the business model of living labs themselves, such as Katzy (2012), who proposes a business excellence model for running and operating a living lab in order to come to a sustainable business model for the lab itself. However, the explicit integration of business model research for the resulting innovations in living labs is very rare. Moreover, in his literature review of the most influential living lab papers, Schuurman (2015) discovered that the majority dealt with the living lab organizations. This focus feels contra-intuitive as living labs are regarded as innovation instruments and innovation intermediaries that are capable of closing the gap between research and market introduction (Almirall & Wareham, 2011). Therefore, we would expect much more attention for the living lab project activities and practical guidelines about how to approach innovation projects in a living lab setting. The majority of the academic living lab literature focuses on explicating the defining characteristics of living labs, such as the user-centricity of the approach. The more practitioner-oriented publications tend to focus on how to set up a living lab, how to involve users, or how to carry out a living lab innovation project from start to finish (e.g., the FormIT methodology) but, to our knowledge, there are no guidelines or instruments on how to integrate business model activities in living lab projects or how to structure user interactions in line with business model development.

Therefore, in this article, we focus on this project level and look for innovation management guidelines in living labs. After a review of the living labs literature, we introduce how we iteratively constructed the Innovatrix framework, which is based on existing innovation management and business model tools and frameworks and is informed by the experience of more than 80 living lab projects. We then investigate the practical implementation of Innovatrix by means of three case studies selected from a sample of 40 living lab projects that used the framework.

Innovation Management in Living Labs

Living labs are regarded as complex phenomena where three analytical levels can be distinguished: the organizational level, the project level, and the level of individual user interactions (Schuurman, 2015). The defining elements of living labs – real-life context, multi-stakeholder, multi-method, active user co-creation and medium- to long-term duration (Schuurman et al., 2013) – are situated among these three separate but interlinked layers. The multi-stakeholder characteristic especially applies to the organizational level. In this domain, Leminen (2015) provides a very diverse overview of actor roles and management implications for living lab networks. Managing value-capture and value-creation processes within living lab organizations is crucial for their sustainability, but it is also cumbersome (Schaffers et al., 2007). This challenge also resonates with the medium- to long-term element. On the user-interactions level, end-user co-creation is regarded as the way to involve users. The literature describes various ways and strategies to facilitate the process of co-creation (e.g., Kristensson et al., 2008) and provides an overview of different user characteristics and user roles (Leminen et al., 2014; Schuurman & De Marez, 2012) of living lab participants.

The real-life aspect and the multi-method approach are characteristics that can be linked to the project level. There is some literature on the real-life aspect and on context (e.g., Bergvall-Kåreborn et al., 2009), but we will focus in particular on the multi-method nature of living lab projects. These projects are described as a structured approach to open and user innovation (Almirall & Wareham, 2008; Leminen et al., 2012; Schuurman et al., 2016). Therefore, living lab projects should be examined at from an innovation management perspective to define which method should be used at what time in the project and how the project is structured. However, living lab papers on methodology tend to describe a very specific methodology, which is specific for a certain living lab, or an innovation process with rather fixed elements and building blocks (e.g., Bergvall-Kåreborn et al., 2010). The most concrete are the works of Pierson and Lievens (2005) and Schuurman and co-authors (2016) who put forward a quasi-experimental design with a pre-test, an intervention, and a post-test. Next to this, there is little to no literature that looks at innovation management in living lab projects, with the exception of some studies on "living-labs-as-a-service" (as described in the next section). This is surprising, as already in 2006, at the start of the living labs movement, Niitamo and co-authors stated that, "[i]n Living Labs there is a need to combine highly self-organized and self-managed processes with multi-disciplinary R&D and innovation management processes." Ståhlbröst (2013) also defines a living lab as "an orchestrator of open innovation processes focusing on co-creation of innovations in real-world contexts by involving multiple stakeholders with the objective to generate sustainable value for all stakeholders focusing in particular on the end users." Nonetheless, this view has not led to an abundance of papers and studies that unravel or describe this process of orchestration.

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Leminen and Westerlund (2017) presented a study that categorizes innovation tools in living labs. There they conclude that the majority of living labs do not yet have standardized tools but rather use custom-made tools, which is an indication of the immaturity of these living labs in terms of operations. However, the authors remain vague regarding the nature and applicability of these "tools". Äyväri and Jyrämä (Äyväri & Jyrämä, 2017; Jyrämä & Äyväri, 2015) see living labs as perfect instruments to investigate and define the value proposition of innovations and look into three existing tools and how applicable they are in a living lab context: the Value Proposition Builder (Barnes et al., 2009), the Value Proposition Canvas (Osterwalder, 2012), and the People Value Canvas (Wildevuur et al., 2013). However, they conclude that none of these tools takes into account the role of the wider context, the service ecosystem, and the role of networked actors as resource integrators. Moreover, none of the tools explicitly points out the role of enterprises as intermediaries in building invitations for value co-creation.

Because a living lab as an open ecosystem offers specific opportunities to develop new business models and tested value propositions, we believe a dedicated tool for business models and living lab activities can and should be crafted. Therefore, within this article, we present Innovatrix, a hands-on tool that takes into account specific living lab characteristics and that builds further on existing tools. Innovatrix can be used as an innovation management approach that also enables practitioners to discover the impact and outcomes of living lab interventions.

Business Model Components as Innovation Management Elements

A notable exception in the search for innovation management anchor points for living labs can be found in the scant literature on "living-labs-as-a-service". These living labs, focused on delivering specific services to external customers, play the role of innovation intermediary between entrepreneurs and end users (Ståhlbröst, 2013). Coorevits and Schuurman (2014) argue that the validation board (http://leanstartupmachine.com), from the lean startup methodology, can be used as a tool to structure living lab projects as it is focused on planning and executing user research. Rits and co-authors (2015) argue for the integration of business model research with user research in living labs. In this context, they refer to established tools linked to business modelling and technology entrepreneurship, such as the Business Model Canvas (Osterwalder & Pigneur, 2013), the Lean Canvas (Maurya, 2012), and the Value Proposition Canvas (Osterwalder et al., 2015). D'Hauwers and colleagues (2015) proposed the iLLAB, a hypothesis-driven living lab framework incorporating both user and business model learning that based on elements from the above business model tools. They see the iLLAB tool as an aggregation of principles from Ries (2011), the Osterwalder Value Proposition Design (2015), the business model matrix of Ballon (2007), the business model canvas of Osterwalder (2010), and Porter's five forces model (1985) that is translated into a set of strategic components. They developed their own framework to gather assumptions for user research, as the input from the other frameworks remained too high-level to define and execute user research. The validation board (Ries, 2011) functioned as the main framework as it puts the customers at the core and focuses on the customer hypothesis, the problem hypothesis, and the solution hypothesis. This is also in line with the work of Wildevuur and colleagues (2013), who designed the People Value Canvas (PVC) tool to help build value propositions during user-centric service development processes. The PVC consists of nine building blocks describing the input that has to be provided to establish the value proposition. The PVC is an iteration on the Business Model Canvas and facilitates a process-oriented approach, more specifically for highly iterative (and lean) innovation processes allowing for structured learning and pivoting.

However, how can we structure these elements in order to link them to the (living lab) innovation process? Herregodts and colleagues (2017) developed a framework on knowledge uncertainties in order to tackle this issue. Within these innovation uncertainties, a major distinction can be made between knowledge related to the current environment versus knowledge related to the innovation under development. While the first is closely related to problem and opportunity identification, the second is related to the formulation and evaluation of solutions. This framework is based on the metaphoric use of "states". States relate to reference points, either from the perspective of the organization or the individual (Gourville, 2005), where the existing, "current state of being", the "as is", or "status quo" is opposing "possible future states" (Alasoini, 2011). In the next sections, we will introduce the Innovatrix framework, which is based on elements from the previously discussed frameworks and tools, but which also takes into account this dichotomy between current and future state-knowledge. The Innovatrix originates from the Lean Validation Board but was iteratively modified based on hands-on application in living lab projects.

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From Lean Validation Board to Innovatrix

Innovatrix was developed within imec.livinglabs (previously iLab.o and iMinds.livinglabs), one of ENoLL's founding members and a forerunner in the network in terms of business orientation. At first, when still operating under the banner of iLab.o, the living lab projects followed a rather linear innovation methodology, quite similar to other known living labs such as Testbed Botnia (FormIT) (Almirall et al., 2012). However, as the number of projects and the organization itself started to grow, the need was felt to adopt a less linear approach that was more in line with the concrete issues the living lab customers experienced. To this end, in 2014, the Lean Validation Board was used in the projects to map and validate assumptions during the project as suggested by one of the new team members who had used the Lean Validation Board in her previous working experience. However, soon it became apparent that the validation board did not work optimally in a living lab setting, as the different elements are not really linked and there is less process involved, which made its use limited to the start of the project. Therefore, it was decided to start creating a custom-made innovation management canvas to map and validate assumptions and containing the most critical elements of a living lab innovation (see D'Hauwers et al., 2015 for a more thorough discussion on these development steps). Eventually, Innovatrix was born, consisting of eight elements informed by what we deemed from our practical experiences are most crucial for living lab innovation. To this day, 86 living lab projects have been carried out within imec.livinglabs and 40 have used Innovatrix, whereas the other 46 either used no (business model) canvas, used the lean validation board, or used a premature version of Innovatrix (see D'Hauwers et al., 2015). By having multiple customer segments, each with their own needs, etc., this canvas appeared to be more process-oriented, which made it easier to use as an innovation management tool. We see this as the biggest differentiation from the other business model canvasses, as Innovatrix starts from the user (customer segments) and assumes that different user or customer groups each have their own distinctive needs, current practices, etc. In short, it allows practitioners to link and differentiate the different elements with and for different user groups, which also allows them to capture the outcomes of living lab activities, such as co-creation activities with different users.

We now briefly introduce and discuss the criteria that compose the Innovatrix: Customer Segment, Current Practices, Needs, Value Proposition, Solution, Barriers, Value Capture, and Key Partners (Figure 1). Below, each of these eight components is discussed in detail. We also indicate whether these elements belong to the "current state" or appear "as is" without the innovation, or if they are related to the "future state" or are yet "to be" with the innovation. For each of the criteria, we also introduce "checks" or questions that can be used to fill out the different criteria.

Customer segment – Current state
As used in the Validation Board (Ries, 2011) and the Business Model Canvas, Innovatrix starts from customer segments. However, there is room for multiple customer segments. Also, the other elements are all linked to customer segments and do not necessarily apply for all segments. This approach enables more fine-grained assumption development. In the Innovatrix framework, there is room for three customer segments (the grey areas in the framework) to cater to the need for clear focus through limited scope. The first column is used as an overarching column to map similarities between defined segments. Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Customer Segment criteria: *What customer segments should be focused on? What are the key characteristics? What is the use context?*

Needs – Current state
Osterwalder (2015) includes customer jobs, pains, and gains in the Value Proposition Design canvas, which is the basis for the needs identification in the Innovatrix framework. Furthermore, Ries (2011) links customer segments – customer problems and the fit with the potential solution or value proposition. Following the application of Innovatrix, checks can be used to gauge the need for relevant input into the Needs criteria: *What are the needs of the customer segment? How do we prioritize these needs?*

Current practices – Current state
One missing pillar in Ries (2011), Osterwalder (2010), and in Ballon (2007), is the competition and the differentiation of an SME/startup/innovator. Competition refers to the Five Market Forces of Porter (1985), which draws from the five forces model. The five forces make up the attractiveness of a market. The five forces can be defined as: 1) the degree of rivalry within the industry, 2) the threat of new entrants, 3) the threat of substitutes, 4) the bargaining power of suppliers, and 5) the bargaining power of buyers. Assessing rivalries within the industry can help identify the difficulties of entering the market. If, for example, the market consists of multiple strong players (i.e., an oligopoly market), the need

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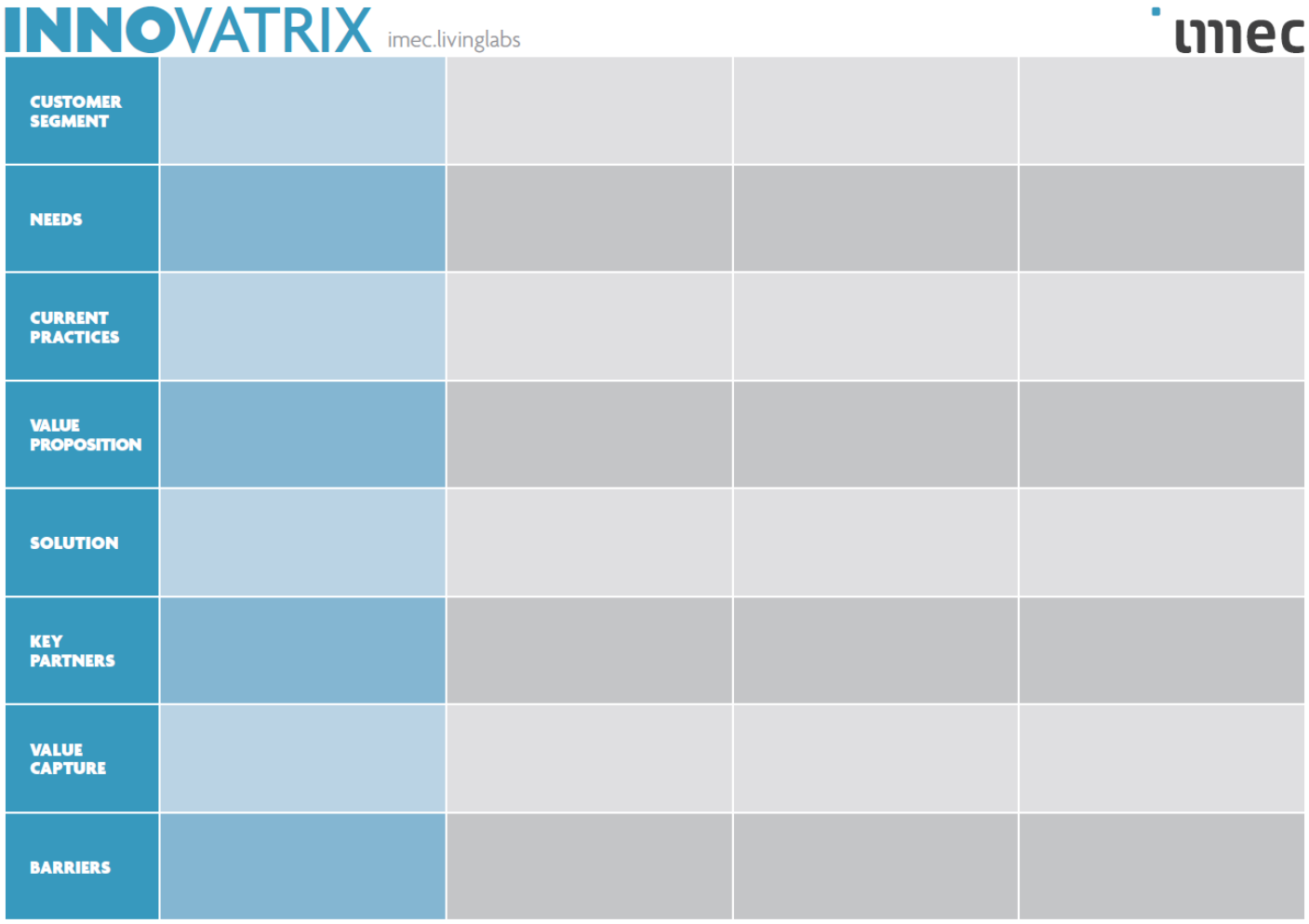

Figure 1. Innovatrix assumption and validation matrix (Available for download and printing in A0 and B0 paper sizes at http://timreview.ca/article/1225)

to diversify can lead to high barriers to entry. On the other hand, if several new entrants enter the market (i.e., monopolistic competition), it could indicate that it is an attractive market with lower barriers of entry. For some products or services, one can find possible substitutes that can serve as an alternative to the specific service or product. Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Current Practices criteria: *Who are competitors, alternatives, and customers, and what is their behaviour? What are the pains and gains of these current practices?*

Value proposition – Current and future state
The value proposition is covered by the Lean Matrix of Ries (2011), the Value Proposition and the Business Model Canvas of Osterwalder (2010, 2015), and by the Business Model Matrix of Ballon (2007). The value proposition is the match between the needs of customer segments and how this can be solved with the solution provided by the innovator. Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Value Proposition criteria: *What (measurable) impact will we create for this customer segment?*

Solution – Future state
The solution refers to "the functional architecture" of Ballon (2007) in the Business Model Matrix. The functional architecture comprises the technical systems, which are composed of at least one building block (or module) governed by specific rules (or intelligence) that interwork (or not) with other technical systems through predetermined interfaces. The composition of

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the solution in the key modules and technical systems enables the researcher and the innovator to identify the unique selling point of the innovation compared to the competition. This division is less explicitly included in Osterwalder (2010), even though the difference can be significant in certain innovations. Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Solution criteria: *What are the components of our (digital) solution? How do these components differ for the different customer segments?*

Value capture – Future state
Ballon (2007) included the financial model in the Business Model Matrix, which described the revenue model and the revenue-sharing model. Osterwalder (2010) also takes into account the revenue model, where the pricing level and the pricing model are mentioned. Therefore, we opted to utilize the definition of "value capture", which comprises the pricing model and the pricing level, and in cases where revenue sharing is applicable, this section can be utilized. The application of the Innovatrix framework in different projects shows that partners can face difficulties identifying their pricing model and pricing level, and thus this needs to be included in the framework. Value capturing has an important link with how pressing the customer need is and to the associated value the partner promises to deliver. Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Value Capture criteria: *What value (monetary and non-monetary) do we receive in return? What price should we set (and how)?*

Key partners – Future state
The value network definition is an alternative to the broad, market-based approach of the Business Model Matrix of Ballon (2007). In the value network analysis, however, the applicability is more adapted to innovations in the form of partnerships required to deliver the innovation to the customers and with whom do innovators need to collaborate. Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Key Partners criteria: *Who are our key partners? How should we interact with stakeholders?*

Barriers – Future state
According to Steinkühler and colleagues (2014), self-justification is the most empirically supported explanation for escalation of commitment, the "...tendency to become locked-in to a course of action, throwing good money after bad or committing new resources to a losing course of action" (Staw, 1981). Therefore, Steinkühler and colleagues (2014) argue that self-justification cannot be totally avoided but for de-escalation of the commitments, the search for disconfirming evidence can help. Therefore, it was decided to explicitly include "barriers" as an element to look for this disconfirming evidence. This forces the practitioner to play the role of "devil's advocate". Following the application of Innovatrix, checks can be used to gauge the need for relevant input to the Barriers criteria: *What are the barriers to adoption, usage, and/or market entry?*

Innovatrix Put into Practice: From Workshop to Innovation Management Process

In practice, the Innovatrix has two uses: 1) as an innovation framework in a hands-on workshop session and 2) as an innovation management process.

First, as an innovation framework, the Innovatrix is used at the start of an innovation project, for example during a kick-off workshop. The most important roles in such a workshop are the trained Innovatrix facilitator and the innovator (or the innovator's team). The workshop starts with an innovation pitch provided by the innovator. After this pitch, the eight distinctive Innovatrix criteria – as described above – are "filled" with relevant input from the innovator. Here, the facilitator plays an important role in the gathering of all relevant input through very specific probing questions in the form of "Innovatrix checks". The gathered input is then awarded one of initially two possible statuses based on the nature and the strength of the input: either assumption (the input has not yet been validated and is thus hypothesized by the innovator) or validated assumption (the input has already been validated through previous activities). Depending on the assumption status, the input is mapped on different-coloured post-its: yellow (assumptions) or green (validated assumptions). The outcome of an Innovatrix workshop is the mapping of assumptions and validated assumptions, followed by marking the most important assumptions as "key uncertainties". Subsequent research activities should focus on these key uncertainties.

Second, the Innovatrix is used in support of the innovation management process. Here, the Innovatrix framework is used as the starting point of a living lab innovation project. The outcome of the Innovatrix workshop, the list of key uncertainties, is then translated into testable assumptions and is matched with appropriate research and innovation activities. Research and innovation activities are then carried out. In the next Innovatrix workshop, the Innovatrix update, the focus is placed

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on the key uncertainties that were object of research and innovation activities. Here, the assumption status is under debate based on the outputs of the research and innovation activities. In an Innovatrix update, the status of an assumption can be changed in dialogue with the entrepreneur with following possible statuses: assumption (the research has not been validated), validated assumption (the input was validated), new insight (new information arose from the research and innovation activities), and invalidated (the assumption was not supported). The Innovatrix is thus used in support of the innovation management process through the mapping and changing of assumption statuses in a structured dialogue with the innovator throughout the entire living lab innovation project. This process is repeated until the end of the living lab project.

Case Illustrations

In order to illustrate the practical application and value of Innovatrix, we looked for illustrative case studies (Yin, 2017) in our sample of 40 living lab innovation projects that made use of the Innovatrix out of the 86 living lab projects that have been carried out by imec.livinglabs since its inception (see also Schuurman & Protic, 2018). For an idea of some of the projects and of the bigger sample, see Schuurman (2015) and Schuurman and co-authors (2016). Common to all the selected projects is the presence of a single entrepreneur or entrepreneurial organization that can be considered as "innovation owner" and the use of at least two different user co-creation or user interaction methods during the project. For each project, a separate online archive is created containing all project deliverables and researcher notes of all customer meetings, including the Innovatrix workshops (where the Innovatrix canvas is filled out together with the entrepreneurial team). Based on these notes and on the project outcomes, we selected three case studies where Innovatrix was used and, in our estimation, provided specific value to the innovation project.

Motosmarty

This project was focusd on a mobile application that detected the driving behaviour of young people in order to give feedback and assess their risk profile. In term of end-user focus, there were no issues as the target population were young people and students. Co-creation sessions, surveys, and user tests were performed to iterate the application. However, in terms of customer segment for the generated data of the application, there was no focus at all. Here, Innovatrix was used to explicate all knowledge and assumptions regarding 17 customer segments (e.g., insurance companies, the government, research institutes). This led to discussions inside the team and made them realize that focus was needed, otherwise they would burn all their resources without finding a paying businesss-to-business (B2B) customer. The application is now on the market as Viva Drive (vivadrive.io), and it focuses on insurance companies and large companies that want to monitor their own car fleets. By using Innovatrix, internal team differences were made explicit and could be resolved, and a clear and motivated focus could be facilitated.

Spott

This living lab project focused on Spott (spott.ai), a new way for users to use their smartphones to recognize, like, share, and buy products they saw during a television show or commercial including, for example, the types of clothing worn by the actors or the objects in the scenes. The Innovatrix workshop at the start of the project indicated three types of end-user segments and the television stations. In terms of value capture, the assumption was that an affiliate marketing fee would be the main source of income for Spott. However, based on the co-creation sessions and field trials with the application, it appeared that the "buying" of items recognized during the television show was not that common, but that more adept viewers felt more connected to the television content itself as they received more information on the objects that were used or worn by their favorite characters. This newly discovered evidence made Spott delete one of the end-user segments, the one that was focused on general viewers buying products. Instead, they focused on potential revenue from television stations paying to use the application for their shows. It was felt that this higher level of engagement with viewers, especially frequent viewers, would attract advertisers and increase their willingness to pay. By visualizing the different customer segments and putting the evidence of the research activities in one matrix, decisions could be made by the innovation team and the business model itself could be iterated. In this project, Innovatrix brought scope, identified unexpected outcomes, and enabled the team to focus on a limited number of segments while taking into account the main sources of revenue. At the moment, Spott has already been launched in multiple countries worldwide and is growing rapidly.

Lab Box

Lab Box is the organization behind Pikaway (pikaway.com), a multi-modal transport application that helps users plan and book trips without being restricted to one or only a few means of transport. At the starting workshop,

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it appeared that the three envisioned customer segments were still rather high level and in need of specification. To tackle this, we performed a segmentation survey and subsequently conducted a field trial with representatives of the user segments. This enabled the team to create persona, which provided focus for the developers to prioritize their development backlog. Moreover, one of the key assumptions captured during the first workshop, the need for a one-stop shop application, could be iteratively validated by capturing the frustrations with the current practices in the segmentation survey and co-creation session, but this was also expressed in the field trial so this was also reflected in the future state (i.e., the Solutions element). During the project, Innovatrix was used as a reporting tool for the different research activities. The tool provided crucial evidence that was used by the coding team that was developing the application in parallel with the living lab project. Moreover, the development team also put forward key questions or assumptions to be researched in subsequent user activities. This approach ensured efficient alignment of research by the living labs team and development by the Lab Box team. At the end of the project, the team from Lab Box asked for the main takeaways and their recommended next steps based on the project. By going through the Innovatrix framework and the modifications step by step, we could easily extract the main learnings and key elements to work on before the market launch. At this moment, Pikaway is available in the app store and a launch in the Play Store is planned for the near future.

Discussion and Conclusion

Although living labs are regarded as orchestrators, which hints at an innovation management approach, there is a lack of literature and studies that further explicate this role of the process. Rather, living labs are described and studied in terms of defining characteristics (such as real-life experimentation, active user co-creation, and public–private–people partnership), but what is left untouched is how these elements should be managed and utilized according to the needs and characteristics of a specific innovation project. For living labs to take the next step in becoming mature and established innovation organizations, we feel that this innovation management role should be further elaborated and that this is even crucial given the inherent complexity of living labs. The three-layered model by Schuurman (2015) provides a useful framework to anchor these elaborations. In our literature review, we noticed that the largest gap in terms of the orchestration role in living labs is situated on the project level. Therefore, within this article, we focused on the question of how innovation management in living lab projects can be facilitated and supported by tools or frameworks.

As a result, we presented the Innovatrix framework, which consists of eight elements derived from existing business model tools and frameworks. The specific characteristic of the framework is that all of its elements should be specified for each customer segment that is identified. Moreover, Innovatrix also clearly distinguishes between the current state elements (the top three) and the future state elements (the bottom four), which gives it a more dynamic, process-like feeling.

Based on a sample of 86 living lab projects, we chose three case studies of projects from the sample that used innovatrix to illustrate how we derived three propositions regarding the use and implications of the Innovatrix framework for Living Lab practitioners.

First, Innovatrix helps to scope the user involvement activities, as it clearly explicates assumptions related to the different customer segments, and it also enables practitioners to indicate which assumptions are key for taking the next steps in the project. This leads to a more efficient use of resources and facilitates the selection of representative users for the given customer segments. It also guides the choice of method to validate the assumption, as seen in the Lab Box case, for example.

Second, Innovatrix forces the project owner to focus on a limited number of customer segments, as there is only room for three to four segments maximum. If there are more segments, the elements of the Innovatrix help to choose between different segments in terms of focus. This approach increases the efficient use of the scarce entrepreneurial resources and helps decision making for the innovation teams, as seen in the Motosmarty case, for example.

Third, Innovatrix allows practitioners to iterate the business model based on the consistency of the Innovatrix elements and to capture the iterations and pivots that were made during an innovation project, as seen in the Spott case, for example.

This approach allows specific outcomes to be linked with certain living lab activities, which has been previously identified rather problematic (see Ballon et al., 2018). Innovatrix serves as a visual summary of key elements and assumptions regarding an innovation project from the viewpoint of the end user. By capturing

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snapshots of the Innovatrix framework before and after a research activity, the modifications and alterations become apparent. To this end, a digital version of Innovatrix is being built that enables practitioners to fill out Innovatrix digitally and keeps track of all changes during a project. Moreover, Innovatrix is also an interesting tool to facilitate the discussion between living lab researchers and the project owners.

To further explore and validate these propositions, further research and more cases are needed to assess the value of Innovatrix. Also, Innovatrix represent a specific view on innovation management and living lab activities but might have broader applicability. It has been used in a "living-labs-as-a-service" context, but it might be applicable in other contexts as well. We encourage uses and tests in other contexts, other types of projects, and other organizations in order to increase the knowledge on innovation management in a living lab context and to help in building a more structural, encompassing Innovatrix for all kinds of living lab projects and activities. We feel that this would increase both the impact and position of living labs as innovation intermediaries.

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