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Living Labs

Welcome to Issue 9/10 of the Technology Innovation Management Review. We invite your comments on the articles in this issue as well as suggestions for future article topics and issue themes.

Editorial: Insights	3
Seppo Leminen and Dimitri Schuurman	
Expect the Unexpected: Investigating co-creation projects in a Living Lab	6
Katharina De Vita and Riccardo De Vita	
Human Factors in Living Lab Research	21
Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, and Tom Van Daele	
A Closer Look at the Role of Higher Education in Living Labs: a scoping review	30
Renée van den Heuvel, Susy Braun, Manon de Bruin, and Ramon Daniëls	
Living Labs for Public Sector Innovation: insights from a European case study	47
Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Røhnebæk, and Francesco Mureddu	
Rural Living Labs: Inclusive Digital Transformation in the Countryside	59
Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, and Diana Chronéer	
Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands	73
Stefano Blezer and Nurhan Abujidi	
A Review of Living Lab Research Development and Methods for User Involvement	88
Judy Hong Huang and Elisa Thomas	
Author Guidelines	108



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Editorial: Living Labs

Seppo Leminen & Dimitri Schuurman

From the Guest Editors

A special issue on the theme of Living Labs in the Technology Innovation Management Review was selected and developed from papers presented at the DLDD and the XXXII ISPIM Innovation Conference, both held virtually in 2021. “DLDD stands” for Digital Living Lab Days 2021, which is organized by the European Network of Living Labs. ISPIM - the International Society for Professional Innovation Management - is a network of researchers, industrialists, consultants, and public bodies who share an interest in innovation management for which the innovation conference is their main annual event.

We understand “living labs” as physical regions or virtual realities where stakeholders from public–private–people partnerships (4Ps) of firms, public agencies, universities, institutes, and users meet, where stakeholders in collaboration create, prototype, validate, and test new technologies, services, products, and systems in real-life contexts (Westerlund & Leminen, 2011). There are growing interests and needs from extant research to further understand and conceptualize what living labs include, but not limited to, typologies (Leminen et al. 2012), research avenues (Leminen & Westerlund, 2016), bibliometric research (Greve et al., 2020; Greve, Vita, Leminen, & Westerlund, 2021), topic modelling (Westerlund et al., 2018), systematic research (Ballon et al., 2018; Hossain et al., 2019; Dekker et al., 2020), and impact (Schuurman et al., 2016; Ballon et al., 2018). Moreover, a lot of other collaborative innovation types and labs that operate in parallel with living labs have emerged such as Fab Labs, makerspaces, innovation labs, innovation spaces, and policy labs, etc. (Schuurman & Tönurist, 2017; Leminen et al., 2021). Further, there are also a plurality of themes and topics (Nyström et al.; 2014; Leminen et al., 2020), as well as industrial sectors, as well as their theoretical and managerial underpinnings (Schuurman, 2015; Leminen & Westerlund, 2019; Greve et al., 2020; Greve et al., 2021).

This special issue on living labs projects shows a range of diverse perspectives, including categorization of user involvement methods, key components, scenarios for living labs, learning outcomes, objectives, outcomes, public sector innovation, urban living labs, and user involvement. It not only further positions living labs as one of the main innovation approaches in the context of

wicked problems and new technological opportunities, but also reveals various methods and techniques applied in living labs.

The first article by De Vita and De Vita analyses 14 project in JOSEPHS® LL, which is located in Nuremberg (Germany) to reveal eight categories of outcomes on the project level in living labs. The study contributes manifold to the living lab literature. Among them, the study proposes This qualitative study reveals findings that add to our understanding of the potential objectives, outcomes, and involvement of stakeholders in living labs.

The next paper by De Witte et al. analyses four cases of Living & Care Lab (LiCalab), located in Flanders, Belgium. The study focuses on human factors in living lab research. The authors contribute to the living lab literature by arguing to incorporate this method within healthcare and other living labs for generating safer and more responsible products and services.

In the third article, van den Heuvel et al. present a literature review by focusing on how to understand learning environments and living labs. To put it differently, the study provides a scoping review of higher education in the context of living labs. Their results encourage involving higher education for analyzing learning activities in living lab contexts to improve learning outcomes.

The fourth article by Hansen et al. analyses 21 in-depth European case studies in nine EU-countries, and also reviews living labs for public sector innovation. The authors propose several contributions to the literature on living labs by discovering three main patterns and scenarios for living lab actors and their organization.

Habibipour et al. in the fifth article focus on empirical data from a single project, “DigiBy” in Sweden’s Norrbotten Region. The study focuses its attention on rural living labs, as a counterpart to the dominant urban living lab activities. The paper contributes manifold to the living lab literature. For example, the study results in five key components that steer the design of digital transformation pilots for emerging rural areas and their stakeholders.

The sixth article by Blezer and Abujidi focuses on three

Editorial: Living Labs

Seppo Leminen & Dimitri Schuurman

cases under the criteria of urban living labs and deals with them by means of a comparative case study with three cases in one city. The study offers multiple contributions for living lab researchers as it sheds more light on the relationship between financing, stakeholder roles, and actual project outcomes.

The final article by Hong Huang and Thomas conducts a bibliometric literature review of user involvement methods during innovation processes in living labs. This conceptual paper analyses and contributes to the living lab literature by discovering eight categories of user involvement methods, which support further theory-building, as well as practitioners looking for practical guidelines.

The selected articles offer and draw a cross-section of living lab research relevant for researchers and managers. We warmly acknowledge the multiple contributions of the selected articles for the living lab field in this special issue, while also further encouraging scholars around the world to enrich the extant research traditions of living labs to tackle innovation challenges that are visible in real-life environments and with multiple stakeholders.

This year we celebrate the 10-year anniversary of the Special Interest Group (SIG) on living labs within the International Society for Professional Innovation Management (ISPIM). This group has fostered yearly contributions to the innovation conferences, including invited speaker sessions, dedicated sessions with paper and practitioner presentations, development sessions, and workshops. We invite researchers to submit their living labs papers for the next ISPIM Innovation Conference on "Innovating in a Digital World" to be held in Copenhagen, Denmark from June 5th-8th, 2022 and to join us in celebrating the 10-year milestone of the SIG, as well as the 15-year anniversary of the European Network of Living Labs (EnoLL).

Seppo Leminen, and Dimitri Schuurman
Guest Editors

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Editorial: Living Labs

Seppo Leminen & Dimitri Schuurman

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Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita and Riccardo De Vita

“If you look at history, innovation doesn't come just from giving people incentives; it comes from creating environments where their ideas can connect.”

Steven Johnson
Science author & media theorist

Living Labs (LLs) are complex multi-stakeholder environments that enable real-life testing and experimentation of products, services, and systems. Despite increasing attention by practitioners as well as policymakers, and growing scholarly interest in the field, the literature exploring congruency between organisational objectives and outcomes when utilising LLs is still scarce. To fill this gap, a qualitative case study is employed to gain an in-depth understanding of objectives and project outcomes of organisations utilising LLs. The LL JOSEPHS® was chosen as this study's empirical context, in which 14 different projects were analysed. In-depth interviews revealed eight categories of measurable project outcomes: market acceptance, price acceptability, exposure, product testing, market intelligence, legitimisation, method testing, and networking. This study not only highlights what companies have achieved in comparison to their original project objectives, but also identifies additional unplanned outcomes that they accomplished. The findings offer important project-level insights into the potential and limitations of LLs. The results form a basis upon which to develop a better understanding of how innovation performance can be nurtured in LLs. Insights from the study may also help firms and facilitators by providing a deeper understanding of LLs at an individual project-level, and by articulating potential objectives and outcomes associated with organisations' involvement in LLs.

Introduction

Living Labs (LLs) are complex multi-stakeholder environments that enable real-life testing and experimentation of products, services, and systems. Commonly viewed as a practical tool for pursuing innovation through co-creation, LLs have enjoyed increasing attention from scholars, policymakers, and practitioners. Despite a growing literature (Greve et al., 2020), the actual performance of LLs remains under-researched (Paskaleva & Cooper, 2021). Rudmark, Arnestrand, and Avital (2012) suggested that “understanding the key to co-creation success must draw on the motivations of the relevant stakeholders to engage in the process”. While practitioners and

academics have discussed the benefits gained from co-creation, little is known about what motivates different stakeholders to participate in co-creating innovations (Pedrosa, 2009). Research tends to focus on understanding the motivation of users to engage in co-creative activities (Zwass, 2010; Ståhlbröst & Bergvall-Kåreborn, 2011; Roser et al., 2013; Roberts et al., 2014; Georges et al., 2015), however, the literature on objectives that organisations wish to address and achieve in LLs is scarce.

To guide firms and facilitators on how to utilise LLs, more knowledge is needed regarding company drivers for participating in innovative co-creation processes. Furthermore, an organisation's objectives need to be

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

compared against the results of engaging in a LL, in order to understand how far the co-creation project has achieved its purpose. Veeckman et al. (2013) recommended, simply, that “the innovation outcome must be considered”. Yet meanwhile, others have commented that, “the emerging LLs research fails to highlight innovation outcomes” (Leminen & Westerlund, 2015). As “value is always uniquely and phenomenologically determined by the beneficiary” (Vargo & Lusch, 2008), companies utilising the facilitation service of LLs, therefore, determine the value derived from it. While, the success of co-creation projects in LLs can be based on the congruence or discrepancy between planned objectives and outcomes (Gardner, 1977), the literature does not offer such insights. Following Paskaleva and Cooper (2021) who argue that “LLs could be evaluated by whether they deliver the benefits they set out to achieve”, this study addresses the following research questions:

- (i) What are the project objectives of organisations that utilise a LL?
- (ii) What are the realised project outcomes of organisations that utilise a LL?

Following this introduction, we discuss the role of LLs, organisational objectives, and project outcomes, as well as the effectiveness of LLs. The third section outlines the case study approach, introduces the case JOSEPHS®, and defines this study’s data collection and analysis. The findings, in section four, highlight what companies have achieved in comparison to their original project objectives. The fifth section discusses the findings in light of extant literature and presents the study’s contributions to our understanding of LL projects. Finally, we identify the theoretical and practical contributions from this study, as well as limitations of the research.

Literature Review

The Role of Living Labs

LLs find application in many sectors. Their fields of application, as well as attention from policymakers and academics, have grown, particularly during the last decade (Paskaleva et al., 2015; Schuurman et al., 2015; Hossain et al., 2019; Greve et al., 2020, 2021; Paskaleva & Cooper, 2021). LLs are often described as bridging the gap between “open innovation” (Chesbrough, 2003) and “user innovation” (von Hippel, 2005).

LLs are discussed in the literature as performing multiple roles, while also being described as intermediaries, platforms, and networks. Almirall and Wareham (2011) claimed that LLs function as an intermediary between various stakeholders. LLs can perform a variety of activities in the innovation process in their intermediary capacity (Howells, 2006), and thus can also be labelled as agents, brokers, or marketplaces. Katzy et al. (2013) suggested a strategic position for these innovation intermediaries as facilitators with strategic innovation capabilities. Their study recognised matchmaking and innovation process design, management of collaborative projects, project valuation, and portfolio management as such strategic capabilities. For such an intermediary role to be performed effectively, Lapointe and Guimont (2015) remarked on the need for an organisational culture of openness and permeability, in regard to the external environment of companies. They also confirmed that stakeholders utilising LLs identify the need to be sensitised and supported in the development of open innovation know-how through intermediaries. Agogué, Yström, and Le Masson (2013) suggested that innovation intermediaries, such as LLs, can play a valuable role, even when the technologies, markets, and stakeholders are unidentified, and where there is a need for communal action beyond the sole company to discover new opportunities.

Users play a vital role in LLs as they contribute to the co-creation of new products, services, and systems. Extant literature commonly discusses the drivers of customers and users to participate in such activities (Antikainen et al., 2010; Roberts et al., 2014; Georges et al., 2015). However, LL literature focusing on the specific objectives that drive companies to utilise such environments is scarce.

Organisations utilising Living Labs

Organisations engage in co-creation projects as a way to understand their customers better, and, as a consequence, they can turn the insights they derive from this into innovation and a competitive advantage. For organisations utilising a LL, the process begins with setting project objectives. Bhalla (2014) identifies three categories that classify such objectives. Firstly, Generation refers to cases where the company’s objective is to obtain ideas, suggestions, or designs from customers and other stakeholders. Secondly, Refinement includes cases where collaborators work with the firm’s representatives to refine the features of a

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

product or service. Thirdly, Creation refers to situations where both collaborators and a company's professionals work together to develop a completely new product or service (Bhalla, 2014). Leminen and Westerlund (2012) point out that a LL serves as a platform for addressing both the shared goals of LLs and the goals of individual stakeholders. Existing literature documents the benefits associated with engaging LLs, but also some of the potential challenges and risks with co-creative activities.

Hoyer et al. (2010) recognise several positive co-creation outcomes, such as increased productivity and efficiency gains through cost-minimisation. Furthermore, a faster speed to market (Alam, 2002) and a closer fit with customer needs (Fang, 2008) can be achieved through co-creation. However, Hoyer et al. (2010) also acknowledged the costs and risks associated with co-creation. For example, companies may experience diminished control with regards to strategic management and business planning. In addition to decreasing control, the empowerment of consumers may lead to greater complexity in managing the company's objectives, given the interests of diverse stakeholders involved in the co-creation process (Hoyer et al., 2010). Edwards-Schachter, Matti and Alcántara (2012) suggested that LLs help to recognise peoples' needs, their preferences, as well as expectations for innovation opportunities using a specific methodology. Aside from identifying community needs, the findings also show that LLs are a beneficial instrument for improving local development and support, as well as integrating technological and social innovations in policies and local governance processes. In LLs, the knowledge emerging in experimentation phases often delivers unexpected insights, whereas more predictable knowledge is often produced in the co-creation and exploration phases (Lehmann et al., 2015). The same study also suggests that emerging knowledge might increase in complexity along the phase progression of a LL project, as stakeholders and users become more informed and experienced about the services they are co-developing (Lehmann et al., 2015). Magadley and Birdi (2009) offered insights into micro issues, such as creative outcomes, human-technology interaction, group dynamics, and facilitators. The findings suggested that innovation labs may positively influence creativity. This positive impact can be credited to the main conceptual ingredients of innovation-oriented facilities, such as a time and place to participate in creative thinking and the technology needed to facilitate such a process. Yet, the study stressed another important

characteristic, which is human facilitation, or the impact of people. In spite of the potential positive outcomes associated with LLs, Grotenhuis (2017) highlighted that some LLs remain underutilised. Building on the experience of several LLs, the scholar emphasised the importance of better coordination between LLs, the companies, and ecosystems they serve to fully exploit LL potential. LLs can indeed offer many benefits to organisations, facilitating the provision of a wide variety of services, ranging from new R&D projects to joint business development.

Effectiveness of Living Labs

Ballon, Van Hoed and Schuurman (2018) suggested that LL aims are manifold, as they "bring digital innovation processes and outcomes more in line with user preferences and practices, discover unexpected uses, identify potentially sound business and revenue models, stimulate cooperation between stakeholders, enable specific stakeholder groups to influence design features, increase acceptance, understand and tackle inhibiting factors, minimise failures, or study effects of introduction". Supporting earlier findings (Schuurman et al., 2016), Ballon et al. (2018), however, stated that impact assessment of LLs remain anecdotal.

Lewis and Moultrie (2005) proposed a framework as the foundation for analysing the structure, infrastructure, benefits, and dis-benefits of innovation labs. Similarly, Magadley and Birdi (2009) assessed the effectiveness of an innovation lab as a new approach for endorsing creativity in companies. The study expanded on the research of Lewis and Moultrie (2005), not only by assessing an innovation lab by means of various research approaches, but also by viewing the phenomenon entirely from the user perspective. Veeckman et al. (2013) put forward five recommendations to achieve a successful implementation of projects. They suggested that a LL should establish: (i) a clear strategic intention, (ii) a minimum of shared value creation and sharing among all stakeholders, (iii) a minimum level of openness, (iv) a minimum set of users that establish strong communication, and (v) a mixed set of LL tools to discover new opportunities. Paskaleva and Cooper (2021) examine the effectiveness of LLs through a systematic review of extant literature. The study criticises that the benefits of using LLs are often only presented as leading to "innovation" and "development". The scholars further critique the high-level, non-specific, nature of authors' discussions about

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

benefits that they claim occur from the use of LLs. Paskaleva and Cooper (2021) conclude that “outcomes from LLs are still poorly understood”.

Our study contributes to filling this research gap. While substantial efforts have been made to understand the motivations of users to engage in co-creative activities in LLs, a more fine-grained understanding of companies’ objectives to engage with LLs is required, to help more properly understand the effectiveness of LLs. Although, Bhalla (2014) identified three broad categories of objectives for companies to engage with LLs, which refer to the generation, refinement, and joint creation of ideas, the study does not provide a list of specific and measurable objectives that companies would like to address. To guide firms and facilitators on how to fully utilise LLs, more knowledge is needed regarding the companies’ specific objectives for participating in a co-creation process. Paskaleva and Cooper (2021) argue that “LLs could be evaluated by whether they deliver the benefits they set out to achieve”. While the success of co-creation projects in LLs can be based on the congruence or discrepancy between planned objectives and outcomes (Gardner, 1977), extant literature does not cover such insights.

Research Approach

Given the exploratory approach in this study and the research question, a qualitative case study was employed to gain an in-depth understanding of the outcomes of organisations using LLs (Yin, 2015). Only a limited number of studies discuss specific LL project objectives and outcomes; furthermore, LL projects are commonly studied across various empirical contexts. To eliminate potential biases due to the heterogeneity of LLs (Ballon et al., 2018), one LL was chosen for the empirical context of this study, facilitating a comparison across 14 different projects taking place in such an environment, each represented by a different company.

The case JOSEPHS®

JOSEPHS® is a LL based in Nuremberg (Germany). It incorporates key LL features as defined by Westerland and Leminen (2011). In line with their definition, JOSEPHS® offers a real-life context in which authentic use situations are created and studied. In this physical space, various stakeholders can contribute to the innovation process. JOSEPHS® has also received multiple awards for its innovation, as well as its research activities.

The 400 m² open setting of JOSEPHS® attracts co-creators through four different areas: the living lab, a think tank, Café, and the Gadget Shop. The LL area is where companies have their products or services tested by users. This open space is divided into five business islands, each occupied by a company for three months under one common theme. JOSEPHS® also has a “Think Tank”, which is often used to run university seminars, events with an external speaker, or lead user workshops for companies to further deepen their co-creation activities. JOSEPHS® in addition hosts an Italian Café. Positioned right at the entrance, the café attracts visitors without them necessarily knowing that JOSEPHS® has more to offer, which helps in lowering barriers to interaction. Finally, the smallest space within JOSEPHS® is occupied by Ultra Comix’s “Gadget Shop”. The shop offers gift ideas, such as board games and books.

JOSEPHS® projects can be described by reference to three key phases. First, a briefing takes place to clarify the JOSEPHS® concept and set realistic expectations for collaboration. One of the key objectives in this first phase, is to establish the project’s research design. A research question that the company would like to find answers to is articulated. Second, the three months test phase starts. The prototype is presented at JOSEPHS®, and facilitators encourage users to test it and provide feedback. User feedback is then presented back to the companies in order for them to review their prototypes and make possible adjustments throughout the testing phase. Third, qualitative and quantitative analyses are performed on the feedback collected throughout the three months. In accordance with the individual agreement, a report, a presentation, or both are presented back to the company. Feedback to companies comprises results as well as recommended actions.

Data Collection and Analysis

Semi-structured interviews with 14 individuals from various organisations were carried out between April and June 2017. The interviews were recorded and transcribed. An overview of the organisations interviewed is provided in Table 1.

During the interviews, study participants were asked questions about their objectives to engage in a LL project, as well as the anticipated project outcomes, including planned and unexpected results. Based on grounded theory, the data was analysed with no preconceived hypothesis (Glaser & Strauss, 1967). In line

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

Table 1. Study Participants

#	Company (Fictional Names)	Participant's job role	Interview Duration	In-person or telephone interview
1	HomeConcepts	Enterprise communications manager	1h 20min	In-person
2	Imagine Institute	Innovation and Intrapreneurship Manager	34min	Telephone
3	SleekSoftwareSolutions	Director Research & Innovation	1h 19min	In-person
4	CitizenChampions	Dean of Design Department	24min	In-person
5	Technology Institute	IT specialist & Application developer	34min	Telephone
6	SmartComfort	Head of Corporate Technology	1h 02min	In-person
7	AmazingAccessories	Creative Director	59min	In-person
8	IT4Tomorrow Institute	Project leader & Academic coordinator	30min	In-person
9	LearningLounge	Management Consultant	1h 19min	In-person
10	RadicalRethink	Founder & CEO	39min	In-person
11	Innovation4Society	Researcher	27min	Telephone
12	YoungStar	Founder	1h 06min	Telephone
13	MyMoney	Product manager mobile	1h 29min	Telephone
14	HomeGrown	Co-founder & Managing Director	25min	Telephone

with Glaser and Strauss (1967), this study employed the constant comparison method by following a non-linear process of coding, comparing, and memoing of data, along with identifying project objectives and outcomes. Through this iterative process, concepts that explained patterns in the data were developed. Our data analysis continued until theoretical saturation was reached (Glaser & Strauss, 1967) and no further categories of project objectives and outcomes were identified. Taking into consideration the challenges of measuring project success in LLs, we adopted a goal-based approach in examining the congruence or discrepancy between planned objectives and outcomes (Gardner, 1977) as an indicator for project success.

Project Objectives and Outcomes

For LLs to be effective and to be able to facilitate co-creation, first it is helpful to understand what motivates organisations to utilise such spaces. This study finds that companies engage in co-creation for different

reasons, which mainly belong to two broad categories. On the one hand, companies wish to gain access to co-creators, and, on the other hand, they would like to gain access to the LL itself. Within these two areas, the interviews reveal seven different types of objectives involved in why companies engage in co-creation. Table 2 provides an overview of project objectives against realised outcomes, distinguishing between planned and unplanned outcomes.

In total, we identified eight realised co-creation outcomes. Seven out of these eight correspond to the objectives driving companies to engage in co-creation at JOSEPHS®.

Companies stressed the importance to them of receiving feedback from a diverse range of co-creators. The feedback they seek relates to market readiness, price acceptability, exposure, product testing, and market intelligence. The only category not mentioned as a project objective by any company was

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

Table 2. Project objectives and outcomes

Company Code	Type of Transactions	Project Objectives and Outcomes							
		Access to Co-creators						Access to JOSEPHS	
		Market acceptance	Price acceptability	Exposure	Product testing	Market intelligence	Legitimation	Method testing	Networking
SmartComfort	B2B	X			X		✓	X	
HomeConcepts	B2C	X	X	✓					
Imagine Institute	B2B	X							X
SleekSoftwareSolutions	B2B	X							
CitizenChampions	B2C	✓		X					
Technology Institute	B2C	X	X						✓
AmazingAccessories	Both	X		✓			✓		X
IT4Tomorrow Institute	B2B	X	X				✓		
LearningLounge	B2C	X							✓
RadicalRethink	B2C	X		X					✓
Innovation4Society	B2C	X						X	
YoungStar	B2C	X	X	X		X			
MyMoney	B2C	X					✓		
HomeGrown	B2C	X	--		0				

Symbols. X objective achieved; -- objective not achieved; O objective not achieved for company internal reasons; unplanned project outcomes

“legitimation”. For four companies, however, involving co-creators in the project enhanced their internal decision making. Therefore, legitimation is an unplanned project outcome that companies did not anticipate or consider. Four companies that were interviewed pointed out the importance of accessing JOSEPHS® as a resource in itself. Companies would like to access JOSEPHS® as a way to test the suitability of the LL as an innovation method, or to access its wider ecosystem and to network with many different stakeholders.

Only HomeGrown has not achieved all its project objectives. Most companies, instead, achieved more project outcomes than what they had intended. All unplanned, and therefore, additional project outcomes were considered beneficial to the company, apart from CitizenChampions that received insights on market acceptance of their product but did not consider this feedback useful to them.

Market acceptance

The project objective that was mentioned the most was

market acceptance. Out of 14 companies, 13 stated that they are interested in understanding if their product or service is satisfying customer needs. HomeConcepts stated that, “we want to present our ideas and concepts, before they are fully finalised and are on the market” (HomeConcepts). The company wanted to examine customer perception of the product and identify “what is important for the user”.

The interviewee from SleekSoftwareSolutions stated that their “aim was to get as much user feedback as possible” because “we don’t have in our sector many research projects for the end customer [as] we offer mostly b2b solutions”. As the development of the app was already well on the way, the company implemented a continuous development cycle of one to two weeks, when the developers were posing questions that required further investigation through the co-creation project at JOSEPHS®. Simultaneously, they were incorporating feedback from the users at JOSEPHS® to update the app according to the suggestions received.

LearningLounge presented a new company website and

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

posed questions related to navigating their main page as a way to test new features. In contrast to clickstream analytics, JOSEPHS® offered a more comprehensive platform to gather information about user experiences navigating the LearningLounge website and their cognitive associations with different ideas and concepts.

Establishing contact with end-customers was stated to be of particular importance to SmartComfort, which operates in a B2B context: “We had in the past [...] not much direct contact to the end-customer and can’t really accurately say how the end-customer [...] perceives our products, how they assess it and what suggestions of improvement the customer may have” (SmartComfort interviewee). In the context of their specific products, SmartComfort stated, “We have realised that we need to get much closer to the end-customer”. Through JOSEPHS®, SmartComfort was able to test market acceptance of two technologies in comparison to one another, directly with end-customers.

All 13 companies achieved their original project objective with regard to understanding market acceptance of their product or service. Overall, four different kinds of results could be observed.

Firstly, five companies received completely new insights through their co-creation project at JOSEPHS®. For example, Technology Institute was confronted with “some uncomfortable questions” indicating where the ideas from the company differ from “what the customer actually wants”. While some of the feedback given was already known to the company, they also realised “that there are sometimes expectations or ideas - sometimes quite funny ideas, that we didn’t think of before and that motivated people on our side to think again about what direction we want to develop the product”.

In other cases, co-creators confirmed pre-existing assumptions from companies, or provided feedback that led companies to readjust their approach during the testing phase. While IT4Tomorrow Institute met their objectives, they also experienced challenges in receiving content-related feedback, as they were less interested in the product’s design aspects:

“We are interested in opinions regarding the content and not design. Many, many visitors said the box on the [product] is too big, it is way too big and way too heavy. [...] Many still focused on the

design and just after we told them, that we are already aware of it then they told us other content related feedback. It was really difficult to make people not think about the design, but about the content. That was tricky”.

For this reason, it was important for the company to reflect on interim feedback and thereby adjust its approach. Integral to the success of the project were the information guides who conveyed guidance to the co-creator, by steering them to aspects about which the company wished to receive feedback.

Finally, one company completely changed its business model as a result of their co-creation project at JOSEPHS®. HomeConcepts reflected on their experience at JOSEPHS® and stated that it “opened our eyes”. The interviewee explained that the project had a far-reaching impact on the overall offering: “We completely left our original thought [about] how to offer [a] technology supported [service] to our [clients]”.

Price acceptability

Another objective for companies to engage with JOSEPHS® related to price acceptability. Five of the companies wanted to find out what customers are willing to pay for their products and services. The comment from HomeGrown was particularly direct in its meaning: “We wanted to find out especially what price range people are expecting. What are people willing to pay for the product?” HomeConcepts initially developed a concept that was very pricey and potential customers pointed out that they could not afford such a high price point. The company asked JOSEPHS® co-creators what they would be willing to pay for a specific service. To avoid overengineering a concept that would not be affordable for a mass market, HomeConcepts posed some questions to JOSEPHS® co-creators: “What is important for them? What can they imagine?”

YoungStar even “increased the price [of their product] by 200 Euro [...]. In this case, [it had] just positive, and no negative effects”. While four companies met their objective, one of them also had to test aspects that could influence the price. Technology Institute wanted to understand if customers would prefer an entire device or an app. JOSEPHS® co-creators favoured an app: “We already had that idea but we didn’t know how much people would be interested in that, but it became apparent that it [...] is worth pursuing” (Technology Institute interviewee).

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

HomeGrown, on the other hand, did not meet its initial objectives and was unable to define a price range for their product. HomeGrown explained that the quality of the data was not satisfactory: “It was difficult because the quality of the data was not sufficient. For example, we have 20 questionnaires that state that the customers are willing to pay two euros for the device, which is of course not very useful for me”. Considering the complexity of the device, the suggested price is far below any reasonable assessment: “As a consequence, we intend to further test the price, maybe in a different setting”.

Although JOSEPHS® openness was beneficial to companies, staff also had to consider the specifics of a prototype and the suitability of co-creators to provide input. This could be considered in the data processing phase to allow for more differentiated feedback.

Exposure

JOSEPHS® offers exposure to companies and their prototypes. While some companies may see this as a natural consequence of their engagement with JOSEPHS®, three companies we studied specifically identified exposure as one of their project objectives. This is different to the companies trying to examine market acceptance through co-creator feedback, as these companies were identifying exposure as their objective, and did not actively seek feedback from co-creators at JOSEPHS®. CitizenChampions stated that, “we didn’t really have an objective. We just wanted to introduce [the product]”. Similarly, RadicalRethink explained that, “my expectation was mainly the exhibition”. Furthermore, the latter interviewee explained that the objective was to exhibit the product to “the walk-ins, but also the people that have been invited by JOSEPHS®”. YoungStar, a start-up from the region, also articulated product exposure as an objective of their project: It was “somewhat also about showing the [product]”.

Different to the three companies, HomeConcepts and AmazingAccessories did not define “exposure” as their original project objective; however, both explained that this was nevertheless an unplanned project outcome. For example, AmazingAccessories explained that they “received good media coverage”. The local newspaper “Nürnberger Nachrichten published an article”, which the interviewee described as “a good side effect”. AmazingAccessories did not plan to achieve such exposure, but acknowledged the positive impact it had:

“We were able to communicate it well locally that we are currently having an exhibition at JOSEPHS® and that was positive”. Similarly, HomeConcepts recognised that the project was “also beneficial for the [company] image. You are at JOSEPHS®; that raises awareness, [and] who knows what people go in and out there”.

Product testing

Two companies explicitly used JOSEPHS® to test their products from a technical point of view. For example, an interviewee of SmartComfort stated, “My objective was to see how the installation of the two systems work out in general. [...] Just the fact that something like that was installed on-site; to find out how smoothly it works”. The results of this product test were not only “used for the development of their own products but also to assess the products of [an Acquisition Company]”. Product testing for the Acquisition Company was an important consideration for the possible acquisition:

“At that point the ‘Acquisition Company’ was not part of SmartComfort. It was in the preliminary stage in [the] context of ongoing discussions, so that one could also test the format of JOSEPHS® to find out where does this company stand, what can they do, what can’t they do, to strengthen our assessment, which was very valuable”.

HomeGrown also stated that testing the device and its functionality at JOSEPHS® was one of their project objectives. However, it did not achieve their objective due to internal reasons. HomeGrown intended to conduct product testing with their device: “Originally, we wanted to observe how the device copes for one and a half months without supervision”.

Market intelligence

One company, YoungStar’s objective is to collect information that can be used in defining market opportunities, market penetration, or market development. Their objective is to gather market intelligence: “To know where customers are from helps us with the decision where we want to open a shop. Where can we expect good returns?” To understand where the customers are from, YoungStar offered “some coupon codes on a blanket, worth 10 euros”. As a result of this initiative, the company had co-creators redeem their coupon: “We could see who used them and know that we benefited financially from the project” (YoungStar). Furthermore, the company could also draw a conclusion from the initiative in terms of the location

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

of their customers.

Legitimation

“Legitimation” was the only category of project outcomes that was not mentioned as an initial objective to engage in co-creation at JOSEPHS®. Yet, four companies explained that the involvement of co-creators in the project legitimised their actions and endorsed decision making internally. Additionally, it supported communication external to the company.

For example, MyMoney identified that the feedback from JOSEPHS® co-creators provided more legitimacy internally to the company: “We have clear user-feedback and this user-feedback is taken more seriously than the feedback of our family and friends. And our board completely agreed”. SmartComfort similarly used co-creator insights from JOSEPHS®: “I also used it internally, not only to raise awareness for JOSEPHS®, but also used the results to bring on certain decisions. [...] We discussed it with the board, because it is quite rare that we do these sorts of activities”. External to the company, IT4Tomorrow Institute acknowledged that, it “helps us when we talk to our clients and producers. We can tell them that we did end-user polling and we know that you can produce this in price range”. Similarly, based on the feedback from co-creators, AmazingAccessories stated, “Through JOSEPHS®, you get rid of your gut feeling and get a rational profound sample size, that you can rely on and that you are able to work with. You no longer have to act blindly, because you know, okay, I now have the numbers to confirm this”. Involving co-creators at JOSEPHS® also legitimised AmazingAccessories’ actions: “When I tell the distributors that we went to Fraunhofer and tested it over three months in a LL and that we have a solid base of results, that is of course completely different than if we say, we tested it on one colleague and he said it is this way and that’s now how it is. That has a completely different weight when you have actual data behind it”.

Method testing

Two of the interviewed companies stressed their interest in testing JOSEPHS® as a method for co-creation. SmartComfort explained that they wanted to understand the following,

“How does such a probe work with JOSEPHS®? How many people come? How many people participate? How does the supervision work on-site? How much do you have to directly engage in the

supervision and evaluation as a company and how much does JOSEPHS® do? I would say also [it is] a test of the service of JOSEPHS®, because for us it is obvious, that we want to use those kinds of format more often in the future and for that you have to start somewhere”.

Innovation4Society explained, “We gained some interesting methodological insights that we will make use of in the future”. Also, SmartComfort stated, “We met our internal objectives, and we also were able to meet our hidden objectives”. The latter refers to the method testing of JOSEPHS® as a LL, which SmartComfort did not openly communicate to JOSEPHS® staff. The interviewee described their experience as “a very smooth cooperation, that was implemented well. One never had the feeling of being left alone, because we received information proactively, which we could use. We [will] consider repeating it [this experience] for different products”. SmartComfort was satisfied with using JOSEPHS® as a method and would use the LL again for future projects.

Although, only two companies explicitly articulated method testing as an objective, all companies that utilised JOSEPHS® are likely to have reflected on their experience and whether JOSEPHS® met their expectations or not. On a scale from 1 (not successful) to 7 (extremely successful), all companies except CitizenChampions (1), and HomeGrown (4) rated their project success as 6 or 7. Therefore, we conclude it is likely that they were also satisfied with JOSEPHS® as a method. Considering the variety of companies that utilised JOSEPHS®, their satisfaction provides evidence of the LL's adaptiveness.

Networking

Establishing new contacts through JOSEPHS®' wider network of stakeholders was a stated objective for two companies. AmazingAccessories and Imagine Institute explicitly aimed to expand their network. Furthermore, Technology Institute, LearningLounge, and RadicalRethink also benefitted from networking opportunities, yet they did not define this as one of their original project objectives.

AmazingAccessories was hoping “that maybe one or two distributors might come by, see it and buy a few for their shops”. Imagine Institute met their objective to expand its network: “Through the feedback new contacts were made”. The interviewee stated, “There was one project

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

on smart school gear and then there was one evening at JOSEPHS®, where some people from schools and the education industry were there. And there was also a school backpack manufacturer there and we were able to connect. So customer engagement at JOSEPHS® held true”.

Regarding unplanned project outcomes, three additional companies reported that they benefitted from the networking opportunities that arose as a result of their co-creation project at JOSEPHS®. LearningLounge was able to expand its network by establishing contacts with JOSEPHS® staff “and, of course, behind that [was] also the Fraunhofer Institute”. An employee from LearningLounge “facilitated workshops here, and he attended as a guest the re-launch [of JOSEPHS®] as well”. As a result of the co-creation project, Technology Institute received “two additional but really interesting enquiries that came through the JOSEPHS® exhibition”. Aside from the originally defined objectives, RadicalRethink also benefitted from the project through events and networking at JOSEPHS®: “I got to know JOSEPHS® and I was able to listen to other presentations that were really interesting, and also visit a[nother] project”. Those examples also stressed the value of connectedness that JOSEPHS® has to offer to the stakeholders that engage in their facilities.

Discussion

This study aimed to investigate the objectives and the congruence with realised project outcomes of 14 companies that utilised a LL. Interviews with companies revealed that they have difficulties in quantifying the success of a project. MyMoney, for instance, said that “one can’t evaluate it on one figure alone, because there are too many factors that one has to consider, and that can’t be expressed in a number”. Similarly, LearningLounge stated that, “coming up with a number is very, very, very difficult”. Indeed, companies emphasised that their success is expressed through the attainment of their often-qualitative goals. Taking into consideration the challenges of measuring project success in LLs, our research examined the congruence or discrepancy between planned objectives and outcomes (Gardner, 1977) as an indicator for project success. From a practical perspective, comparing project objectives to realised outcomes also allowed companies to learn from their experiences, and thereby adjust their actions and expectations for future co-

creation projects.

Project Objectives

Supplementary to previous studies, this research provides a list of specific objectives, which can be measured and are associated to particular organisational activities and functions. LL literature in this area is, indeed, particularly scarce. Our paper expands the framework from Bhalla (2014) by adding more specific co-creation objectives to the three high-level ones identified.

Some of the objectives discussed in the paper have already been identified by existing studies (see Table 3). Market acceptance (Ponce De Leon et al., 2006; Hsiao & Yang, 2010; Buhl et al., 2017) and networking (Niitamo et al., 2006; Juujärvi & Pessa, 2013), for example, are mentioned in the literature, but only as assumed co-creation objectives, and without them being really explored. Product testing is also identified as an objective in the work of Schumacher and Feurstein (2007). The authors state that LLs carry out product tests with users prior to the final launch of new products and services. In the context of this research, however, the value of product testing was recognised also when done earlier in the development phase.

Results from this research, therefore, expand current knowledge about the objectives firms have to carry out co-creation in LLs, which is done in two ways. Firstly, we provided a list of measurable objectives, associated with access to the LL itself or its co-creators. Secondly, while some of the objectives identified in this paper are partially acknowledged in the literature, the empirical evidence gathered allows for deeper discussion and understanding, thereby adding to current knowledge about co-creation in LLs.

Project Outcomes

This research makes important contributions to knowledge about co-creation outcomes in LLs. In addition to identifying specific project outcomes and highlighting what companies achieved in comparison to their original project objectives, the research discusses additional unplanned outcomes that companies accomplished. In this study, seven out of the eight categories of co-creation outcomes were found to be consistent with categories in the project objectives; this section referred to them as “planned outcomes”. In addition to planned outcomes, we also identified one new category of unplanned project outcomes:

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

Table 3. Summary of Project Objectives and Contributions from this Research

Project Objectives & Outcomes		Existing Literature	Contributions
Access to Co-creators	Market Acceptance	Ponce De Leon et al., 2006; Hsiao & Yang, 2010; Buhl et al., 2017	
	Price Acceptability		X
	Exposure		X
	Product Testing	Schumacher & Feurstein (2007)	
	Market Intelligence		X
	Legitimation		X
Access to JOSEPHS	Method Testing		X
	Networking	Niitamo et al., 2006; Juujärvi and Pesso, 2013	

Legitimation.

Moreover, this research recognised that companies not only seek input from co-creators, but also from JOSEPHS® itself. Although the current literature acknowledges the involvement of multiple stakeholders in the co-creation process (Schaffers & Kulki, 2007; Feuerstein et al., 2008; Almirall & Wareham, 2011; Westerlund & Leminen, 2011), the focus predominantly lies on co-creators, their ideas, suggestions, and feedback, which ultimately produces value to the companies. Thus, these findings expand on the current literature, which predominantly stresses the value user feedback generates for companies (Dutilleul et al., 2010; Nyström et al., 2014), by accentuating the value that the LL, itself, can deliver to firms as beneficiaries of LL services. The project objectives and outcomes identified in this study are summarised in Table 3 and compared against existing studies.

Innovation Potential

This study highlighted the innovation potential of LLs through three particularly interesting observations.

Firstly, a variety of objectives drive companies to engage in LL projects (see Table 2) and companies tend to pursue a multiplicity of them simultaneously. Further, more than half of the companies examined in this study achieved more outcomes than what they had anticipated. Indeed, some companies obtained user insights and answers to questions that they had not posed or even considered, which underpins the innovation potential of LLs. One possible explanation for achieving unplanned and unexpected project outcomes is the open enquiry process and role played by facilitators in eliciting feedback from users.

Secondly, this study also highlighted that while most companies do not identify “legitimation” as an initial project objective, almost one third of the companies studied recognise it as an unplanned outcome. The findings revealed that companies value testing with users as it reinforces and supports their communication with internal and external stakeholders.

Thirdly, while extant literature has discussed several benefits derived through the involvement of customers and other stakeholders such as universities and

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

suppliers in the innovation process, this study also recognised the value that LL facilitators add to the process. For example, companies wanted to engage with JOSEPHS® also because of their experience with LL projects. Since the opening of JOSEPHS®, LL staff have been able to acquire considerable tacit knowledge there over time that is not easily accessible to others. Yet, through the interaction and guidance of JOSEPHS® staff, companies were able to tap into the tacit knowledge gained in the LL and make use of it in the context of their own project.

All of these reasons might lead organisations using LLs to achieve unexpected results that go beyond their original objectives. Despite the mismatch between some companies' project objectives and outcomes, the innovation potential of LLs seems evident as the projects we studied generated new insights, verified existing assumptions, provided contextual information, or delivered completely unplanned insights triggering a virtuous learning process.

Conclusion

Overall, we identified seven categories of co-creation objectives in this study, four of which have not been addressed in the LL literature: price acceptability, exposure, market intelligence, and method testing. Furthermore, this study also recognised that companies not only derive value from the involvement of co-creators in the innovation process, but also through interaction with LL facilitators. Furthermore, this study also reported eight categories of co-creation outcomes, both planned and unplanned, that companies achieved through their LL-based project. Extant literature has not provided insights about the measurable outcomes of co-creation projects in LLs, thus making this a novel contribution.

In addition to the theoretical contributions, this study has also made several contributions to practice. This research will be of particular interest to managers, LL facilitators, and policymakers. An understanding of various objectives that can drive involvement with LLs is fundamental for managers to fully understand the potential associated with co-creation activities. Co-creation offers companies and their network of stakeholders important opportunities for innovation, as each stakeholder provides access to new resources. The interaction process between stakeholders, therefore, can provide them with opportunities to facilitate value

creation for and with each other (Grönroos, 2008).

The research findings show that this is relevant for companies across industries, irrespective of their size, who want to utilise a LL as effectively as possible. This study provides project-level insights that can support companies' innovation endeavours and highlights the potential, as well as the limitations, of LLs. The examples provided throughout the paper, even when anecdotal, can trigger reflection from managers about the applicability of LLs to various contexts, as well as the suitability of LL methods to achieve different purposes.

This study is also of importance to LL facilitators. As the core service of a LL is to facilitate co-creation by acting as an interface between multiple stakeholders (Mulder & Stappers, 2009), it is important for a LL's staff to understand the objectives of various stakeholders involved in the process. To encourage companies to engage in the co-creation process, it is important to understand what they expect from co-creation (Füller, 2010). Therefore, it is an essential prerequisite to first investigate what drives organisations before a facilitator can help develop the capacity to address their aims. This study identified seven reasons why companies engage in co-creation at JOSEPHS®, which helps outline how the processes can be facilitated. Furthermore, the planned and unplanned project outcomes, identified through this study, can also inform LLs' communication strategies, so that they can articulate their value proposition more clearly, to help set and manage expectations consistently.

Finally, this study is highly relevant for public body stakeholders. As policymakers and local governments support LL activities by providing financial and legislative resources, as well as geographical space (Katzy, 2012; König & Evans, 2013; Karvonen et al., 2014), the findings of this study offer important insights in explaining how innovation performance can be nurtured in LLs. This study can help policymakers to better understand what works in practice, and what kind of policy environment is needed in order to support regional and national innovation efforts more effectively. For example, based on this study's insights, public authorities can establish conditions to enable more companies to engage in LLs. Public funding can be made available for companies that utilise a LL in accordance with specific requirements.

Despite the study's contribution, some areas call for

Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

additional consideration. Firstly, given the exploratory character of the research, the identified objectives and outcomes can be tested in a larger and different sample of organisations and with respect to other LLs. Furthermore, from a methodological approach employing a longitudinal perspective would allow researchers to map changes in the way organisations engage with LLs, including the ability to define and measure their objectives.

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Expect the Unexpected: Investigating co-creation projects in a Living Lab

Katharina De Vita & Riccardo De Vita

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Katharina De Vita & Riccardo De Vita

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Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, and Tom Van Daele

“ At the least, we deserve things that work. At the best, we deserve products we can rely on to make life better, safer, healthier and more satisfying. ”

Christopher P. Nemeth
Principal Scientist, Applied Research Associates, Inc.

Human factors research is still in its infancy in healthcare and other fields. Yet it has the potential to allow organisations and living labs to assess and improve innovation quality, while closely involving potential end users. “Human factors” involve a scientific focus on the interaction between individuals and systems with the goal of improving safety, performance, and user acceptability. Studies simulating challenging real-life circumstances in selected samples and using a multi-method approach can provide important insights for organisations and governments and allow for better and safer services for the end user. By combining existing theory and case examples, the current paper aims to situate human factors research and to help researchers determine when and how this methodology could be applied.

Introduction

The study of human factors and its relevance for living labs

The study of “human factors” involves a scientific focus on the interaction between human individuals and systems with the goal of improving safety, performance, and user acceptability (Bergman, 2012; Weir et al., 2020). The term “system” can refer to specific tools, technologies, or tasks, a general working environment, or in some cases even a social, political, and/or economic environment (Weir et al., 2020). This broad scope and interest in wider systems distinguishes the study of human factors from related fields, such as ergonomics, usability, and user-centred design, although the terms are often used interchangeably (Norris, 2009). Human factors can be situated on the crossroads between engineering and psychology, since they involve both the design of tools and environments, as well as the cognitive and social functioning of users (Parker, 2015). While human factors were first studied in safety critical industries, such as defence and aviation, the approach has gained entry to a broader field of design and safety management in the past decade (Norris, 2009). In the meantime, a Systems Engineering Initiative for Patient Safety (SEIPS & SEIPS 2.0) was

developed with a human factors framework specifically tailored to healthcare (Holden et al., 2013). While research generally concerns itself with outcomes, human factors research has a strong complementary focus on processes. For example, SEIPS 2.0 focusses on the work system, processes (physical, cognitive, and social/behavioural), and outcomes (Holden et al., 2013). Instead of merely assessing whether a system improves efficiency or user outcomes, it is important that research also focuses on safety, ease of use, contextual fit, and implementation processes.

Human factors are of great interest to living labs since these innovation ecosystems aim to facilitate the development and optimization of innovative solutions and hold an intermediary position between the relevant stakeholders (for example, citizens, regulatory agencies, professional organisations, and developers). Although many definitions exist, the living lab approach can be seen as a methodology centred around the co-creation of innovations through end-user involvement and experimentation in real-life contexts (Dell’Era & Landoni, 2014; Ballon, et al., 2018). Living lab research generally follows an iterative cycle, including exploration, co-creation, testing and evaluation, along with implementation and upscaling (Ballon et al., 2018;

Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

Van Den Kieboom et al., 2019). While actual human factors studies are conducted in the testing phase, all four stages contribute to providing safer and user-friendlier products. Figure 1 provides examples of information relevant to human factors that can be collected in the different phases of living lab research.

To be able to design for safety, performance, and acceptability, it is paramount to collect ample information about the environment in which an innovation is set to be implemented. The *exploration phase* allows for the collection of information on physical, practical & organizational circumstances, as well as current potential safety risks. Circumstances can refer to the actual working environment (for example, amount of space, internet access), or also the subjective experience of a given context, such as cognitive demands (for example, working in a stimulus-rich or noisy environment that influences performance) (Norris, 2009). When *co-designing* an innovation in collaboration with stakeholders, perceived risks, elements of high cognitive demand, and an innovation's usability should be considered. In addition, the fit with existing processes, workflows, and workplace habits should be documented, since this is key to maximizing appropriate and long-term usage. At this point in the cycle, it could be useful to include a hierarchical task analysis, which is widely used as a human factors technique that describes

an investigated activity through a hierarchy of goals, sub-goals, operations, and plans (Stanton, 2017). Such a detailed analysis of an innovation can guide further design and the development of test protocols.

The *testing* phase requires field tests to gain insights into prolonged usage, usage in real contexts with varying demands and circumstances, and latent conditions that are harder to identify in previous stages (Norris, 2009). However, Georges, Schuurman, Baccarne, and Coorevits (2015) have also proposed pre-field or usability trials, depending on the functional maturity of the innovation. A lab-based *human factors study* may not only account for technical difficulties related to lower functional maturity, but may also provide additional opportunities to document interactions and preferences. Finally, when an innovation is *implemented* in the field, monitoring and documentation should continue, since societal needs, challenges, and contexts may change quickly, which requires innovation adaptiveness.

Human factors research suggests that multiple stakeholders should be involved in all stages since the design of innovations is a dynamic process that involves continuous improvement and adaptation. The process is therefore not usually linear in nature, but rather more often allows flexible mobility across the stages through multiple iterations. The goal of living lab research

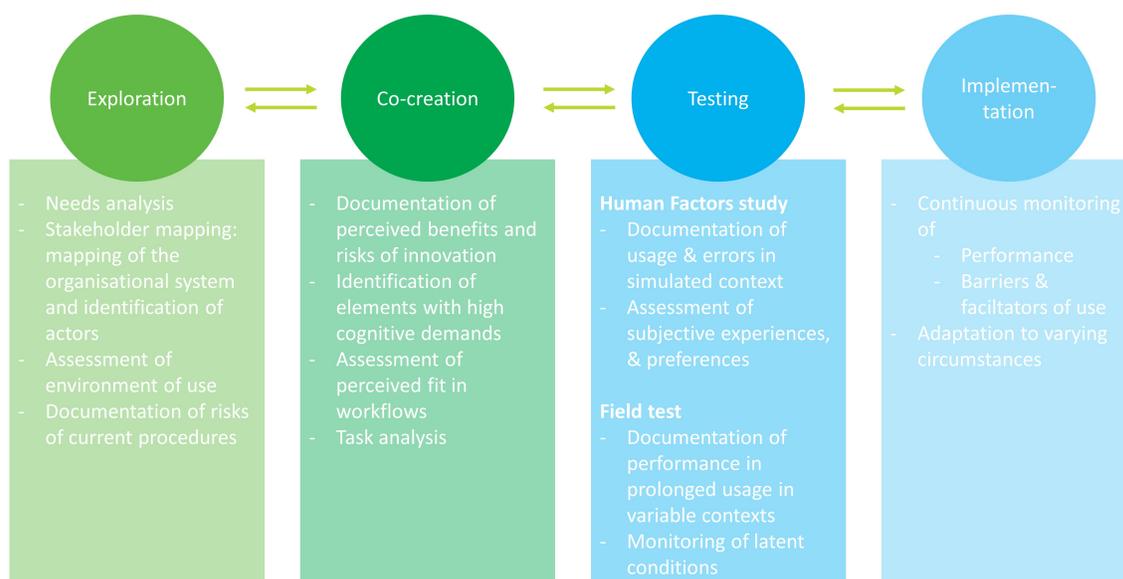


Figure 1. Overview of the different stages of living lab research, along with relevant exemplary focal points for data collection in relation to human factors.

Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

including human factors is ultimately to provide innovations that are relevant, safe, reliable, and easy to use. Nevertheless, insights that are being collected can additionally be used to optimize procedures, shape support materials and training, or validate other process and implementation factors.

Human factors studies

Human factors studies and live tests allow researchers and practitioners to move away from basic assumptions through exploration and co-creation that provide insight into stakeholder perceptions and beliefs. Weir et al. (2020) observe a strong contrast between positive perceptions of technological innovation regarding safety versus data collected on errors and other usability problems in actual implementation. Several testing paradigms can be used to gain insights into human factors. In a “human factors study”, sometimes also referred to as a “usability study”, users are asked to interact with an innovation in simulated real-life circumstances (Bergman, 2012). Table 1 provides an overview of some prototypical characteristics of a human factors study. The design of such studies should always be tailored to the research questions and

innovation of interest.

A human factors study *aims* to provide insights into actual interactions with innovations, and accordingly, usage problems or errors, in challenging yet controlled situations that simulate real life. Having a diverse sample from the target population, including potentially vulnerable targets, allows organizations to design their innovations for their most vulnerable users (for example, those with low digital literacy), which will promote safety and usability. According to the condition or target population, a *sample size* of around 8 individuals is common in human factors studies, and appears sufficient to detect the vast majority of usability problems (Bolle et al., 2016). However, the required sample size can differ depending on the richness of the dataset, and on data collection methods used. Using a lab-based simulated context allows the observation of behaviours that occur widespread over time, or are difficult or unethical to evaluate in real life. For example, we can simulate that a patient has forgotten to take their medication and observe the resultant behaviour, while retaining an ethical basis for conducting the research. Human factors studies can be designed to be very

Table 1. Prototypical characteristics of a human factors study.

Human Factors Study	
1. Goal	To provide insight into actual interactions with innovations in a challenging simulated context.
2. Sample	Recruitment of individuals from the targeted end-user population. Aim to recruit a diverse population in terms of demographics (age, gender, digital literacy), and especially target vulnerable individuals for whom usage might be challenging.
3. Sample size	About 8 participants per condition.
4. Design	One-to-one sessions in which the usage context is simulated by implementing instructions, materials, circumstances, and distractors in tasks as they would occur in real life. Additional inclusion of rare and challenging events helps to uncover potential hazards.
5. Data collection	Mixed method approach, which can include <ul style="list-style-type: none"> - observations (e.g., frequency and nature of usage errors and deviations from ideal use) - instantaneous self-report (e.g., think aloud protocol) - reflections regarding experiences and preferences (e.g., survey, interview) - validated human factors questionnaires (System Usability Scale; Brooke, 1986) - automatic data collection (mouse or eye tracking)

Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

challenging since providing a stringent test of an innovation allows to put rigorous safety precautions in place before it is implemented in practice.

Reviews show that implementation *methodologies* vary greatly, and can include observations, interviews, focus groups, and questionnaires (Valdez et al., 2017; Weir et al., 2020). Most human factors studies implement multiple data collection methods. While the think aloud protocol is a hallmark in the human factors methodology toolkit, the number of studies specifically implementing the “think aloud” paradigm or a “task analysis” remains limited (Valdez et al., 2017; Weir et al., 2020). In the think aloud protocol, also known as “verbal protocol analysis”, participants are asked to perform a task and simultaneously verbally report everything that goes through their mind, unedited, and without evaluation. This protocol provides insight into the cognitions and processes that underlie behaviour. Research generally shows that merely reporting thoughts does not influence a person’s cognitive process, however, being asked about motivations (that is, why individuals are performing actions) could interfere with their natural processes, since it requires self-interpretation (Güss, 2018). The think aloud data is recorded and subsequently qualitatively analysed and coded to extract themes relevant to the study’s particular research questions. An inductive qualitative analysis is typically preferred since it may be difficult to capture the variability of thought processes relating to task interactions in a-priori models and codebooks. Triangulation, or combining several methods or sources of information, can improve trustworthiness of the findings. Thus, we found that an approach combining thinking aloud data with observation checklists or survey and interview data may be preferred (Aitken et al., 2011; Güss, 2018).

The results of human factors studies can help organizations formulate concrete suggestions to improve the design of innovations and community services. However, the impact of human factors studies on the innovations themselves under investigation has often been insufficiently demonstrated or documented (Carayon, 2019; Weir et al., 2020). We suggest that maintaining a good report structure for design and end-user iterations following human factors studies will allow researchers and organizations to better document the effects of their considerable efforts, and also monitor whether further optimizations are warranted.

Healthcare as an exemplary context

Human factors and user-centred design can have a particularly large impact in the field of healthcare, where medical and pharmaceutical dispensing errors, for example, can cause serious, yet preventable, harm (Carayon & Hoonakker, 2019; Weir et al., 2020). Healthcare is a complex and dynamic field with many stakeholders (hospitals, pharmacies, patients, companies, families), whose needs and goals can be very dissimilar. Designing healthcare products, such as medication packaging, can therefore be challenging, and potentially benefit from several iterations of end-user involvement and research that optimizes the design and implementation. In line with this, the UK National Health Services (NHS; Department of Health Human Factors Reference Group, 2012) and U.S. Food and Drug Administration (FDA) have supported and encouraged the exploration of human factors (U.S. Department of Health and Human Services, Food and Drug Administration, Center for Devices and Radiological Health, & Office of Device Evaluation U.S. Department of Health and Human Services, 2016). The following section will describe four exemplary human factors studies from the field of healthcare.

Research Design

While human factors studies have a common goal, implemented research designs can differ depending on the type of innovation, implementation context, or sample. Table 2 provides concrete examples of what a human factors study can look like, based on four healthcare innovation cases executed by Living & Care Lab (LiCalab). LiCalab is a living lab situated in Flanders, Belgium, which primarily focuses on supporting companies and organisations in the health and healthcare sector. LiCalab therefore co-creates, evaluates, and tests innovative solutions with end users.

The authors of this paper were actively involved in each of the listed cases. For the first and fourth case, the team designed the study, performed it in Belgium, and analysed the data. For the other international cases, LiCalab collaborated with other living labs abroad. The study’s design and data collection methodology was discussed in detail upfront with partner organisations. Only for case 3, the LiCalab team additionally supported the other living labs on-site, while the other studies were all set up from a distance. Depending on the goal of the study and the target group, various study components

Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

Table 2. Four case design examples in which human factors studies were implemented in living lab context

Case	Sample and study conditions	Study components
Case 1. Smart medication pack (with app component)	16 participants. Two conditions depending on the medication pack usage instructions.	<p><i>Accelerated 3-day paradigm</i></p> <ul style="list-style-type: none"> - Interacting with a medication pack while being exposed to distracting conditions mimicking real life - Error simulation - Collection of video recordings for qualitative analysis and analysis of observational data with a codebook <p><i>Questionnaire</i></p> <ul style="list-style-type: none"> - Assessment of usability preferences and comparison to alternative design
Case 2. Medication packaging (with mobile app component)	51 participants from three European countries. Two conditions depending on the medication wallet design.	<p><i>Accelerated 15-day paradigm</i></p> <ul style="list-style-type: none"> - Removing tablets from the pack based on users' comprehension of the instructions - Collection of observational data with a codebook <p><i>Think aloud paradigm</i></p> <ul style="list-style-type: none"> - Presentation of a used medication wallet, with the instruction to reflect whether a mistake was made and what the user should do - Collection of video recordings for qualitative analysis and analysis of observational data with a codebook <p><i>Questionnaire</i></p> <ul style="list-style-type: none"> - Assessment of comprehension, instruction and design preferences
Case 3. Visual design of medication packaging	Patients (N=93) and professionals (N = 92; pharmacists, nurses, general practitioners) from 6 countries around the world. Two conditions depending on medication stacking in cabinet.	<p><i>Medication retrieval task</i></p> <ul style="list-style-type: none"> - Performing 8 tasks concerning retrieving medication from a medicine cabinet with packs stacked according to a fixed pattern - Collection of video recordings for qualitative analysis and analysis of observational data with a codebook <p><i>Colour sorting task</i></p> <ul style="list-style-type: none"> - Sorting colours depending on danger and appropriateness for medication packs <p><i>Questionnaire</i></p> <ul style="list-style-type: none"> - Assessing task experiences - Osgood's semantic differential task (Osgood et al., 1957) <p><i>Patient focus groups</i></p> <ul style="list-style-type: none"> - Evaluation of the design in terms of reliability and clarity - Assessment of current medication packaging management, current errors, and how packaging could improve these <p><i>Expert panels (professionals)</i></p> <ul style="list-style-type: none"> - Evaluation of the design in terms of reliability and clarity - Comparisons to other brands - Discussion of how packaging can support use and administration
Case 4. Web-based platform for education and disease management in neurological patients	9 neurology patients together with their informal caregivers	<p><i>Think aloud paradigm</i></p> <ul style="list-style-type: none"> - Presentation of several daily life situations in which the platform could be of use were presented and participants were asked to act accordingly and think aloud while doing so - Collection of observational data with a codebook <p><i>Questionnaire</i></p> <ul style="list-style-type: none"> - Assessment of usability and preferences

Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

were selected to simulate challenging situations that occur in everyday life. The human factors study components could also be combined with other living lab services (for example, co-creation), but these are not included in the table.

In the first case, participants were asked to go 3 days using the smart medication package multiple times per day. Two conditions were designed based on how the product could be implemented in practice, which only differed in their instructions. With the first condition participants only received a folder explaining how to use the smart medication package, while the second condition received additional verbal instruction and a demonstration of tablet removal. Participants were subsequently asked to interact with the smart medication package while performing normal daily activities, such as reading a newspaper article, watching a video clip (simulating watching television), and talking with someone. Their behaviour was observed and documented with the help of a codebook. In addition to normal usage, participants were also explicitly asked to make certain errors so they could experience and comment on the resulting sequence of events on the smart medication package and app. For instance, participants were asked to mimic forgetting to open a medication slot or opening an incorrect slot, so that they could experience and evaluate the resulting reminders and notifications from the medication package and accompanying app, which were designed to support correct medication intake. Observational data was supplemented with a self-report questionnaire on usability and user preferences.

The second case concerns a multi-country design in which two alternative packaging designs were compared. Like case 1, participants were asked to mimic multiple days of removing tablets from the package, while their interactions with the package were observed. In a second task, they were presented with a used medication wallet and were asked to think aloud about whether any errors were made with it, and what the user should do about it. Finally, a questionnaire of participants provided further input regarding their experiences and preferences.

The third and largest international study we did, concerned the visual design of medication packaging. It consisted of a medication retrieval task with 2 conditions that varied with medication stacking, in which

behaviours were observed using a codebook (a subsequent questionnaire also assessed their experiences in more depth). We performed a colour sorting task to assess possible cross-cultural differences in how colours are perceived and interpreted. In the questionnaire, participants were also presented with opposing word pairs (for example, beautiful vs. ugly, strong vs. weak) based on Osgood's semantic differential (Osgood et al., 1957) to explore the connotative meaning of the package design. The design was further discussed and evaluated in patient focus groups and expert panels.

In the fourth exemplary case, neurology patients interacted with a web-based platform while thinking aloud. After receiving a folder with instructions and their login details to access the secure platform, they were presented with situations and questions that they could encounter in real life, and for which they could use the platform. They performed the task together with an informal caregiver, as previous results from co-creation sessions showed that these older or disabled patients would often rely on their support network to help them use such a platform. Data collection consisted of observations as well as self-reported data from a questionnaire.

For all of the four cases above, the project team decided on using human factor studies at an initial kick-off meeting. The safety of participants was considered paramount, and as the health products were still in a minimal viable technical phase, the human factor studies helped them to gain insights into both potential opportunities and pitfalls. To be more specific, observing which aspects of product use led to usage errors in these cases, allowed the respective companies to optimize design. The results and reports of these four cases all had an impact on the design or implementation circumstances of these innovations. Documented changes following the impact of having conducted human factors studies consisted of making a choice between two competing designs, changing terminologies, selecting more appropriate colours, and adapting usage instructions. Two of the cases above included data collection that was performed in multiple countries, which can provide added value for the organizations as customs, perceptions, and opinions can vary across cultures (De Witte et al., 2021). Organizations often aim to launch their product internationally, yet first need to make sure that designs are suitable for a wide range of end users.

Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

Conclusion

Organizations are developing and upscaling new innovations and technologies at an unprecedented pace. However, it is important that these innovations be adapted to the intended user and meet quality standards in terms of safety, performance, ease of use, and contextual fit. Human factors research in healthcare and other fields is still in its infancy, yet it allows organizations to properly assess these aspects of innovations and, if need be, improve their quality. Carayon and Hoonakker (2019) state that, “If we want human factors to be taken seriously into account, we should not be shouting from the sideline, but get actively involved in the design and implementation of health IT, and evaluate the impact of our human factors methods and principles on the technology in practice”. Living labs can play a key role in making sure innovations are safe, efficient, and designed with users in mind.

The current paper aimed to inform the field on how human factors methodologies can be designed and what role they can play in an iterative development cycle. While certain hallmark human factors techniques, tasks, and data collection methods exist, the design of a human factors study will nevertheless always remain a very individual and tailored process given that innovations, circumstances, and targeted end users vary. The study of protocols using a multi-method approach to mimic stringent real-life circumstances and gain insights into error-prone processes can provide important insights for organizations and governments, thereby improving the potential for more responsible, better and safer services for the end user.

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Human Factors in Living Lab Research

Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

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Nele A.J. De Witte, Leen Broeckx, Sascha Vermeylen, Vicky Van Der Auwera, & Tom Van Daele

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A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin, Ramon Daniëls

“ *Coming together is a beginning; keeping together is a progress; working together is success.* ”

Henry Ford

As society changes rapidly, there is a need to educate professionals who contribute to innovation and complex adaptations in organizations. As part of this education, companies, governmental bodies and other stakeholders have sought collaboration on complex issues in “living labs”. Living labs are recognized as educational environments to prepare students in higher education for future roles. The aim of this article is to explore the nature and extent of the scientific literature about living labs in which actors in higher education actively participate. In total, 21 articles were included in this scoping review. Research into this topic appears to be relatively new. Definitions of “living labs” are mostly in line with the definition used by the European Network of Living Labs (ENoLL), with its large variation of lab locations. Few results about organization and governance were identified. Different lessons learned regarding processes, interaction and requirements for successful living labs were found. The design of learning is mostly described by learning activities. Learning outcomes are described in generic and specific competences and assessments in living labs are rarely described. The authors recommend more detailed studies into aspects of the successful participation of higher education to gain knowledge about enhancing learning outcomes, and the effects of educational activities within living lab environments.

Introduction

The world is changing rapidly, leading to complex societal challenges. Continuous social changes affect the types of competences needed for professionals to contribute to innovation. Employers expect professionals to be lifelong learners and to constantly update their expertise in accordance with societal and professional demands. Complex societal challenges call for groups of collaborating experts with different backgrounds and contexts (Cremers et al., 2016). Consequently, there is a need to educate professionals who think and work in an interdisciplinary fashion, who contribute to innovation, and who achieve complex adaptations in organizations. Higher education prepares a substantial group of professionals for “real life”, although it is questionable if traditional classroom courses are preparing students sufficiently for the challenges of the future. According to Zitter, Hoeve, and De Bruijn (2016), the traditional and scholarly approach of higher education is too limited. It does not fit within the “Zeitgeist” of the current era, does not resonate with the preferences of students, and collides with the

demands of professional practice (Zitter et al., 2016). For example, in the Netherlands, Zuyd University of Applied Sciences focuses specifically on developing students into professionals with skills that are relevant for the region. Thus, their main pillars include integrating research into education and embedding education in practice (Zuyd University of Applied Sciences, 2019).

Increasingly, companies, governmental bodies, civil societies, and other stakeholders seek collaboration on actual complex issues in so-called “living labs”. This concept offers opportunities for higher education to work closely with professional practice with the emphasis on innovation research in “real life”. In the literature, the “living lab” concept is increasingly gaining attention (Schoorman et al., 2015). The European Network of Living Labs (ENoLL) defines living labs as “user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings” (ENoLL, 2020). Real-life setting, co-creation, active user involvement, multi-stakeholder participation, and multi-method approach

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

are the five major elements of a living lab (ENoLL, 2020). According to ENoLL, no single living lab methodology holds across the board; all living labs combine and customize different user-centred, co-creation methodologies to best fit their purpose (multi-method approach). The building blocks of exploration, experimentation, and evaluation get performed in iterations, emphasizing the importance of coming to know the current state, designing possible future states of innovations, real-life testing, and assessing the experimental impact by means of user-feedback (Malmberg & Vaitinen, 2019).

Although the concept of living labs has been emerging in the scientific literature and the number of living labs in different areas is increasing, much greater understanding is needed about how to run a living lab successfully. Several aspects of living labs have been the subject of study in recent years, for example, studies into types of living labs and user roles within living labs (Leminen, 2015). In their systematic review, Schuurman et al. (2015) confirmed the increasing number of papers about living labs since 2006, meanwhile the theoretical foundation of the concept lags behind the increasing number of experiences people are having with living labs in practice around the world.

A study into living labs in the Netherlands highlighted the potential value of living labs, though also indicates the current early stage of living labs, and the need for further study (Maas et al., 2017). While the concept of a “living lab” is gaining recognition as an innovative approach for higher education to prepare students for their future roles (Maas et al., 2017), not enough is yet known regarding how to successfully integrate higher education and living labs. Interdisciplinary collaboration poses challenges to all stakeholders involved, such as dealing with differences in professional language and professional culture (Hummels & Vinke, 2010), or shaping the involvement of users in the innovation process (Grove, 2018). Embedding higher education into living labs has its own challenges, including how to merge the dynamics of education and innovation processes into real-life settings, and to match the competences of students with required expertise in the field. Insights gained from reported experiences and lessons learned about how to integrate higher education and living labs, how to facilitate students’ learning in living labs, and how to deal with the challenges it brings along, could provide guidance for future living labs. The aim of this article is therefore *to explore the nature and extent of the scientific literature about living labs in*

which actors in higher education (for example, students and faculty) actively participate. To retrieve this information, a scoping review was conducted using the following research question for framing: *What is known about the role of higher education in living labs in scientific literature and about the factors that influence integration of higher education and living labs?*

Methods

Study design

We reviewed the literature on living labs by means of a scoping review. To accumulate as much information as possible about the concept, our main focus was on article relevance. We used the five-stage approach of Arksey and O’Malley (2003).

Identifying the research sub-questions

We formulated the following research sub-questions for background context:

- What kind of studies are conducted regarding living labs that include higher education?
- How are living labs defined and which models and approaches are used as theoretical underpinnings of the living labs?
- What are features of living labs in which higher education participates?
- What are lessons have been learned regarding integration of higher education in living labs?
- How is learning designed (for example, learning outcomes, learning activities and assessment) in the living labs?

Identifying relevant studies

Our study’s search included two concepts: “learning environment” and “living lab” (Figure 1). Using a literature discovery service from Ebsco Host, we searched 29 different databases simultaneously (including ScienceDirect, CINAHL, Psychology and Behavioral Sciences Collection, PsycARTICLES, Science Citation Index, IEEE Xplore Digital Library, Cochrane Database of Systematic Reviews, ERIC).

The search was limited to publications in Dutch and English published between 2000 and June 2021. In addition to searching electronic databases, we checked the reference lists of relevant articles. We also searched

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

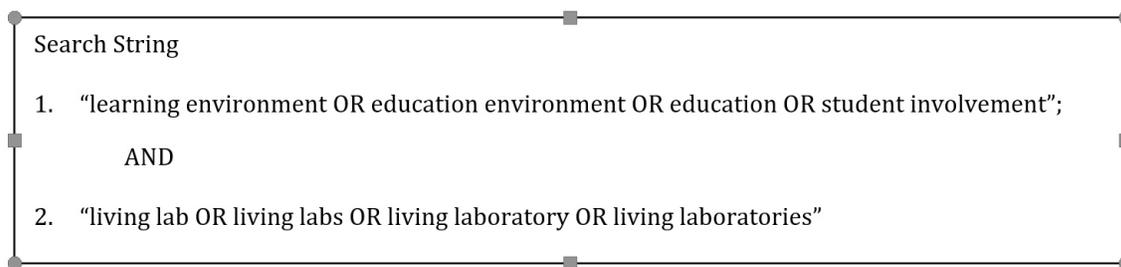


Figure 1. Search string

for journal articles as well as conference papers.

Study selection

The selection of papers based on paper titles was done independently by two reviewers (RvdH and RD). Papers with titles referring to both “living labs” and “education” were given a score of 2, papers with titles referring either to “living labs” or “education” were scored with a 1, and papers on topics that were not relevant to our study were scored with a 0. When the score of the two reviewers together was >2, the abstracts were screened. Screening was performed by one reviewer (RvdH). Articles were included if both “living labs” and “education” were mentioned in the abstract. When the concept of “living labs” was not explicitly mentioned, the article was not included, because this study specifically focused on environments that are called a “living lab”. Other similar concepts may be partly comparable but were also not included because of small nuances between the concepts. Where there was doubt the full text was screened, and the reviewers discussed inclusion or exclusion of the remaining sources together.

Charting the data

A descriptive summary of each study was created in a spreadsheet to map the article’s citation information, general article information (type of publication, number of living labs discussed, domain of the study, subject of innovation, and aim of the study), definitions, key elements and theoretical underpinnings of living labs used by the authors, information on various features, lessons learned, and specific information about how learning is designed within the living labs. First, five articles were independently charted and discussed by two reviewers (RvdH and SB). The results were then discussed with a third researcher, RD. Subsequently, one of the reviewers (RdvH) continued with the other 15 articles.

Collating summarizing and reporting the results

Initial reading and preliminary content analysis led to the main categories described to structure the findings.

After creating the table, the results were summarized, reported and discussed by the authors in order to cluster results and draw conclusions.

Results

The search was performed on June 1st, 2021, resulting in 427 hits. After reading the titles, abstracts, and full texts, and correcting for duplicates, 21 full texts matching the inclusion criteria were selected. Figure 2 shows the selection flow chart of the inclusion and exclusion process. Excluded papers did not meet the inclusion criteria during the screening of the title or abstract because the topics “living lab” and “higher education” were not explicitly mentioned, as described in the Methods section.

Table 1 (supplementary material) gives an overview of all included articles. The first column shows the article reference (citation information). The second column provides general information about the type of study, the number of living labs involved in the study, the domain in which the living lab is situated, the subject of innovation and the aim of the study. The third column reports the definition of living labs as described in the article, often with additional key elements. The fourth column describes the theoretical underpinnings (models and/or approaches) of living labs as reported in the articles. The fifth column identifies the context and features of the living lab (environment), the stakeholders involved, and also the roles and governance structure within the living lab. Column six reports lessons learned involving initiation, evaluation, and sustainability of the living lab, including any success factors and challenges described in the papers. The seventh and last column shows specific information about educational aspects with an emphasis on learning outcomes, learning methods, and types of assessment, which is based on Biggs (2003).

General article information

The selected articles were published between 2007 and

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

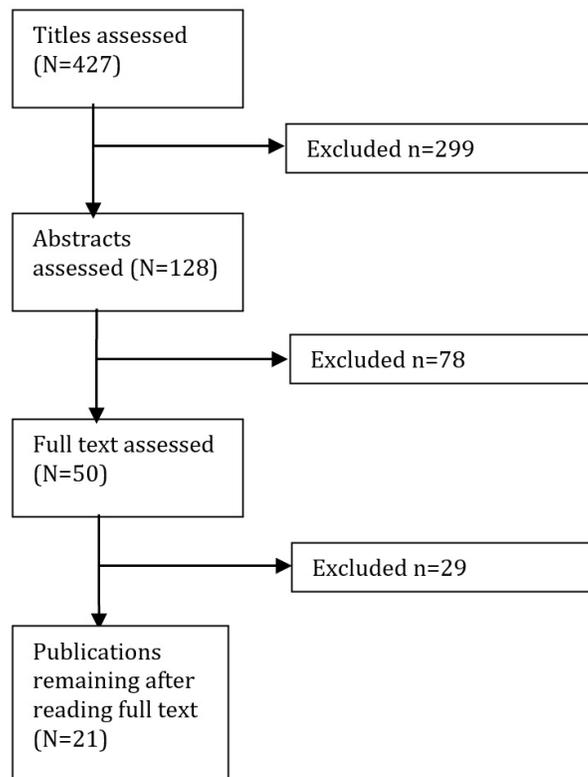


Figure 2. Flow chart of included and excluded articles

2019). The living labs were situated in various domains, including ICT, education, healthcare (occupational therapy, gerontology), industrial design, sustainability, service business development, engineering, tourism, ambient intelligence, and architecture. For example, a living lab in architecture (Masseck, 2017) focused on renewable energy and nearly zero-energy buildings. An example from healthcare is a living lab to establish age-friendly services in co-creation with older adults (Van den Berg et al., 2019).

Aims of the studies ranged from evaluating the experiences of participants in living labs, to exploring or developing the theoretical foundations of living labs, or studying elements of living labs, for example, knowledge management (De Jager et al., 2012). Other aims included what is called “designed serendipity”, as well as the financial sustainability of living labs. For example, Santally et al. (2014) described the theoretical foundations needed to create a framework for a living lab that focuses on classroom education for the future. Van den Berg et al. (2019) studied the experiences of their living lab participants (older adults and undergraduate students) in a way that revealed the importance of equality and shared responsibility.

Students were interpreted as “stakeholders” in all of the studies. Education was explicitly mentioned as the aim of the study in eleven of the articles. For example, Beecroft (2018) describes the interrelations between real world labs and higher education using a social practice perspective.

The types of studies varied. Five articles were qualitative studies or evaluations of living labs, another five described living lab cases/case studies, two were literature studies, and the majority were knowledge syntheses (n=9). Where articles combined several types of study, for example, a literature review together with one or more case studies, the main type of study is reported in Table 1. The number of living labs described in each article varied from one to five. However, most articles discussed a single living lab, often containing several different projects or educational courses related to this lab context.

Definitions, key elements, and theoretical underpinnings
Each article defined living labs differently, although they often used similar wording in their description. For example, “active user involvement” was referred to as “user-centred innovation”, “user-involvement”, “active

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

participation”, or “collaborative development”. All five major elements as described by ENoLL frequently showed up: co-creation, real-life setting, multi-stakeholder participation, multi-method approach, and active user involvement, together with the accompanying building blocks: exploration, experimentation, and evaluation (Malmberg & Vaittinen, 2019). Callaghan and Herselman (2015) defined co-creation in living labs as input from users as co-creators utilized to research the context of ICT use (in this specific case), find new uses, and evaluate new solutions within everyday contexts. Masseck (2017) describes variation in *real-life settings* in architecture, which can range from small-scale knowledge dissemination and “experience homes”, up to city platforms for social innovation regarding sustainability, or a city itself with its buildings and inhabitants perceived as a supporting ecosystem for user-centred innovation. De Jager et al. (2012) highlighted the involvement of *multiple stakeholders*, describing a living lab as an “innovation platform” that engages all stakeholders, such as end users, researchers, industrialists, and policy makers at an early stage of the innovation process. Gualandi and Romme (2019) explained that a living lab can contribute to every phase of the innovation process by orchestrating and coordinating the activities of exploration, co-creation, experimentation, and evaluation. A living lab generates value to the entire supply chain and can explore and assess the environmental, social, and economic effects of new products or services created and tested in the living lab.

Two of the most distinct differences in the definitions of living labs concern specific references to research, learning, and education. Ten definitions explicitly include the element of research in their definition or key elements. An example of a definition explicitly mentioning research is the definition of Era and Landoni (2014) used by Grove (2018): “A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting”. Additionally, the learning or educational aspect is described in six living lab definitions, for example, in the definition of Jernsand (2019) who describes living labs as spaces for open innovation, co-creation and experimentation in real-life settings with students. In their definition, Van den Berg et al. (2019) state that, “*In an educational setting, a living lab enables different stakeholders, including students, to learn how to work on user-driven innovation*”.

Because theoretical underpinnings can play an

important role in a living lab’s operationalisation, and therefore influence the role of higher education, we searched for the theoretical foundations or approaches of each living lab. One article did not explicitly mention a theoretical foundation (Falk-Kessler et al., 2007). In the remaining twenty articles, a broad range of models were described as theoretical argumentation to start a living lab in the first place. Most of these models or approaches focused on processes such as social interaction, pedagogics, or design. Examples involving living labs and higher education include activity theory (Santally et al., 2014), appreciative inquiry (Callaghan & Herselman, 2015), design thinking (Jernsand, 2019), and service learning (Hansen, 2017). Some papers used a very detailed description of their approach, while others only mentioned the model, but did not elaborate on the application details.

Living lab features

All articles described the contexts in which living lab activities took place. Approximately half of the papers described living labs situated in a university department (n=9), sometimes combined with a virtual or web environment. Topics in living labs located at university departments included the future of teaching (Conruyt et al., 2014), as well as sustainability (climate change and urban sustainability, for example, at campus buildings (Evans et al., 2015)). In these examples, a clear relationship is visible between a living lab’s main topic and its location being a real-life environment close to users (in these cases students, lecturers, and others). Other contexts in which living labs were situated involve public spaces, community sites, and cities (n=9). Subjects of these living labs included sustainable tourism (Jernsand, 2019), library services (Kröse et al., 2012), and age-friendly services (Van den Berg et al., 2019). Two articles described a digital/web context, without a physical component, that is, a knowledge management application (De Jager et al., 2012; Grove, 2018). In one article, the living lab environment was labelled as a human-machine interactive environment (Peng, 2010).

Many different stakeholders were involved in the living labs. Two articles described collaboration in the form of a Public-Private-People-Partnership (De Jager et al., 2012; Santally et al., 2014). Hence, living labs can bring together diverse public and private actors. These partnerships include: companies, industry, associations, students (differing study levels and differing study programmes), academics, teachers, researchers, policy makers, end users (for example, older adults), citizens,

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

service providers, and healthcare organizations. The roles and the composition of stakeholders can differ in each phase of exploration, experimentation, evaluation.

Some articles explicated the roles of the stakeholders. For example, students can play various roles, including learners, peer observers, project leaders, data collectors, analysts, and/or presenters. The roles of students can change over time (Falk-Kessler et al., 2007). Lecturers often provided guidance, coaching, and instruction, while end users were able to share their insights or function as mentors or trainers. Some articles emphasized the importance of social equality within the living labs (Van den Berg et al., 2019; Jernsand, 2019). Jernsand (2019) described “flat leadership” as a teaching style employed in their living lab of sustainable tourism, in which lecturers are mentors who listen and advise, rather than only giving directions.

Hardly any information was provided in the articles about the organization or governance of living labs, along with the conditions for sustainability in living labs. In their article, Gualandi and Romme (2019) addressed the financial sustainability of living labs by stressing the acquisition of funding and creation of value, as these are important conditions for living labs to become financially sustainable.

Design of learning

Our main interest was to ascertain if articles addressed the contribution of education to a living lab, and if so, how they designed learning in these labs. We searched for information on the following topics: learning outcomes of students and, where applicable, other stakeholders, if and how activities to enhance learning were described, and if and how articles reported on the assessment of learning in living lab contexts. 14 of the 21 articles mentioned learning outcomes of students in their study. The described outcomes can be divided into the disciplines of generic learning outcomes and specific learning outcomes. Generic learning outcomes were usually more broadly formulated and concerned topics such as professional development, clinical reasoning through lived experiences, reflection (learning-by-interaction), self-regulation of learning, taking responsibility, learning from experience, self-assessment, social awareness, innovation, and collaboration. Examples of discipline-specific outcomes were knowledge of and skills relevant to the development and implementation of age-friendly services (Van den berg et al., 2019), and specific sustainability development competences (Masseck,

2017).

Learning and teaching activities were not described in detail, however, examples of activities presented in this way included “fun learning”, which uses cartoons or story-telling cartoon movies, as well as gaming-to-learn, where learning-by-playing and serious gaming account for an important role in teaching and student learning (Santally et al., 2014). Doing research with others (not only students and teachers), rather than on others (van den Berg, 2019) are other examples of teaching and learning activities in a living lab. These include, developing creative innovations that answer the needs of users, teams working on parallel projects of their own choice, and observing and assessing assignments during lab activities (Falk-Kessler et al., 2007). Hummels and Vinke (2010) connect the term “individual curriculum” to their living lab, giving students an opportunity to select their own learning activities at the start of a semester, thus catering to their individual learning needs. Learning by doing, edutainment, using social media tools, placed-based learning, participatory methods, and workshops are other examples of teaching and learning activities in the context of living labs. Real-life environments that involve users engaging in co-creation are also essential elements in living lab learning activities.

The articles rarely discussed the assessment of learning in living labs. Only three articles described how students are assessed within the living labs; the forms of assessment used were presentations, qualitative assessments during and after activities (reflection seminars, group discussions, course evaluations), progress reports, student blogs, future-driven self-assessment (focus on utilising the programme of study to prepare students to develop sustainable self-assessment ability), exhibitions, and showcases in which students present their work, while coaches and fellow students act as peer reviewers (Hummels & Vinke, 2010). One article reported experiences regarding the assessment of learning in living labs, in which the authors concluded that “there seems to be less competitive pressure” in assessments in a living lab context than in regular assessments in the curricula (Hwawk et al., 2012).

Lessons learned

The articles in our study often addressed lessons learned (including success factors and challenges) regarding initiation, evaluation, and sustainability of living labs. Generally, the lessons learned concern processes and

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

interactions in living labs, as well as preconditions for successful living labs. Regarding the process, van den Berg et al. (2019) found a tension between what is beneficial for a user-driven living lab and what is appropriate for an educational system that focuses on control and prediction. It is deemed necessary in resolving this tension to find the right balance between “freedom and frameworks”. Furthermore, these authors learned about the value of investing time and effort in building relationships between co-creators. Hummels and Vinke (2010) indicate that an attitude of lifelong learning among all participants is essential for creating the right environment in a living lab. According to Grove (2018), “designed serendipity” (unexpectedness, insightfulness, and value added quality) is a success factor as it leads to useful findings and fits within a living lab approach that seeks to elicit unforeseen user ideas and behaviours to enhance product innovation.

Considering interaction in living labs, flat leadership and less competitive pressure amongst living lab participants tend to help to create a successful living lab (Hawk et al., 2012). Using social media tools such as blogs, wikis, Really Simple Syndication (RSS) feeds, sharing content, tagging and social networking were experienced to stimulate the success of a living lab (De Jager et al. 2012).

Requirements for successful living labs include a supportive logistic infrastructure. Falk-Kessler and colleagues (2007) describe the importance of coping with logistical barriers and establishing a community site willing and able to accommodate students during educational activities. Furthermore, building a sense of closeness between stakeholders, including firms and end-users, is seen as a precondition for a successful living lab. Jernsand (2019) also found “neutral places” to be of significance for living labs as they reduce the risk of participants being hampered by institutional “lock-in effects” such as incorporated norms, cultures, and working methods.

Discussion

The aim of this article was to explore the scientific literature on living labs in which higher education actors (for example students and lecturers) actively participates. Potential results could guide higher education programmes and their networks in how to set up sustainable and meaningful collaborations for innovative educational courses, both together with and in the real world. Just as living labs are a relatively new phenomenon, this study also shows that research into

living labs with the active participation of higher education appears to be new. The majority of the papers we studied were published recently, and the number of papers is limited. The *kind of studies* included were mainly descriptive and explorative in nature, reflecting the state of the art in living lab research. Schuurman et al. (2015) also found the number of empirical, quantitative, and comparative studies focusing on the added value of living labs as still rather limited. In our review, we found no studies that focused directly on the effects of learning in living labs.

Definitions of living labs generally involve the main aspects of ENoLL’s definition, meaning a real-life setting, co-creation, active user involvement, multi-stakeholder participation, and a multi-method approach (ENoLL, 2020). This might imply that a consensus exists about what constitutes the core of living labs. Some articles added terms related to education and research in their definition, which, from the perspective of universities, appears to be a logical addition. The fact that most articles do not explicitly mention research associated with living labs might be related to existing perceptions about the process of innovation that research is an inherent part of innovation. A similar assumption can be made about learning in living labs, since one cannot innovate without learning.

However, the inclusion of both students and teachers in living labs calls for active learning, and active learning is of importance for all stakeholders involved. Veeckman et al. (2013) linked living labs to “communities of interest” and “communities of practice”, following the work of Wenger et al. (2002). In these communities, stakeholders are informally connected by what they do together and by what they have learned through their mutual engagement in these activities (Veeckman et al., 2013). This perspective calls for discussion about incorporating learning as one of the core elements of future living lab definitions. Consequently, we can see how giving attention to learning in real life contexts might also impact the *theoretical underpinnings* of living labs. The available body of knowledge about communities (Wenger et al., 2002) and hybrid learning environments (Bouw et al., 2019) support the embeddedness of higher education actors in living labs. Wals, Lans and Kupper (2012) defined a hybrid learning environment as a social practice around ill-defined, authentic tasks or issues, whose resolution requires transboundary learning. For example, available knowledge exists about how to assess students in hybrid learning environments. Zitter et al. (2016) emphasized the crucial role of participants from

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

practice or business in the assessment of students. The selected papers addressed various features of living labs sometimes in detail, and other times generally.

This study revealed that almost half of living labs are situated at universities. This could well reflect the state of the art in the development of living labs in higher education, with universities themselves as both founders and organizers. This circumstance also provokes discussion about the real-life element of living labs versus the merely “academic”. However, the topics of the living labs situated at universities, for example, IT, sustainability, and education, all link to topics studied in which the users of the living lab are themselves users at universities. From an educational perspective, the real-life element of living labs is an innovative aspect for education, offering students experiences outside the classroom.

In her comment about neutral places, Jernsand (2019) emphasized the impact of the location on the success of living labs. Thus, conducting further research into real-life aspects of living labs, including their location, the intensity of interaction between students and users, and the learning experiences of students would be a useful line of approach. It is notable that this study found few research results about the organization and governance of living labs involving higher education. One article concerning innovation networks implies that collaboration in these networks requires clear and SMART goals from the beginning, as well as continuous management of the main elements of the network, and investment in information and communication technology to improve information sharing and formal coordination (van Tomme et al., 2011). In an article on innovation management, the authors stress the importance of a strategy to guide the approach that steers the innovation, the processes, the portfolio, and the projects in the innovation funnel, as well as leadership, resources, and the competences of staff (Igartua & Albors, 2011). The lack of information ascertained by this study might relate to the locations of living labs at universities. In short, the attempt to embed higher education within living labs situated outside of universities may lead to other challenges than those faced by living labs embedded in higher education institutions.

We found several *lessons learned* regarding processes and interactions in living labs, as well as requirements for successful living labs, including the importance of balance between freedom and

frameworks. Furthermore, the literature shows it is crucial to invest in relationships between co-creators. Likewise, less competition and flat leadership with a living lab help to create a successful environment. Moreover, a living lab needs a supportive logistic infrastructure and closeness between stakeholders.

When focusing on *how learning is designed* in living labs, a distinction has been made between generic competences and specific competences. As expected, the specific competences differ between labs depending on their domains and subjects studied. Commonalities among generic living lab competences include co-creation, cooperation, clinical reasoning, and reflection, along with innovativeness and the ability to learn from experience. These competences match the key elements of living labs according to ENoLL, which are a real-life setting, co-creation, active user involvement, multi-stakeholder participation, and a multi-method approach (ENoLL, 2020). The learning activities identified in living labs seemed to be more innovative and interactive in contrast with more classical learning activities. Only three papers reported on assessments in living labs. Although education was part of most research objectives found in our study, we also discovered that none of the studies focused on the effects of educational activities in living labs on the competences of students.

Our aim was to explore the nature and extent of the scientific literature about living labs in which higher education actors actively participate. Other non-scientific papers that discuss this subject were not part of the selection, therefore this review does not capture the full body of knowledge in this domain. It is possible scientific studies that may be relevant could have been missed because of our selection of databases and use of search terms. Our search and selection specifically focused on articles addressing the concept of the “living lab”, as it seems to be an internationally accepted concept, and other reviews of living labs literature have already been conducted as referred to in our introduction. Our finding that all of the articles referred mostly to the same or similar aspects of living labs (as described by ENoLL) supports the assumption that this review capture the concept we were searching for.

Conclusion

Based on this scoping review, we conclude that research on embedding higher education in living labs is still at an early stage. More detailed studies into the participatory aspects of higher education are

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

recommended in order to gain knowledge about enhancing learning outcomes, and the effects of educational activities including assessments within living lab environments.

In addition, knowledge appears to be lacking about conditions, organization, and governance of living labs, and further study would certainly be worthwhile. More emphasis on learning as a crucial aspect of living labs may steer the research and the theoretical foundations that support the embeddedness of higher education in living labs.

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A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

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A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

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Keywords: Living Lab, higher education, scoping review, approaches, definitions, key elements



A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

Appendix 1. Supplementary Materials (six pages)

Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical mode/ approach	4. Living lab context	5. Lessons learned	6. Education	Teaching and self-study methods	Examination methods
Santally et al., 2014	<ul style="list-style-type: none"> Type of publication: knowledge synthesis Number of living labs discussed: 5 Domains: ICT and education Subject of innovation: Classroom based education Aim: Set up a framework for the establishment of a living lab 	<ul style="list-style-type: none"> Definition: environment for user-centered innovation based on a co-creation process for solving problems, but also based on their active participation, with an approach that facilitates their influence in the open and distributed innovation process (participatory design). Key elements: 4 major elements (ENOL): Co-Creation, Exploration, Experimentation, Evaluation 	<ul style="list-style-type: none"> Model: Activity theory, Change laboratory method, Action-research Approach: 4P Innovation: Public-Private-People-Partnership Participatory design and user-centric approaches are key elements. 	<ul style="list-style-type: none"> Context: referring to Living Labs as both innovation arena and an approach (methodology, innovation) Stakeholders: Public and private actors, companies, associations, individual actors, students, academics, research, policy Roles: - Governance: - 	<ul style="list-style-type: none"> Lessons Learned: practitioner-oriented → the following desired end goals to improve the teaching and learning systems. → field experimentation to test new practices → formalized into teaching methods that can be cascaded down to the educators for classroom application (success factor). 	<ul style="list-style-type: none"> Focus on skills development and learning (activity-based approach) 	<ul style="list-style-type: none"> Innovative training of teachers in ICT in the classroom Microscale pil projects: promote integration and use of ICT in the classroom Fun learning Gaming to learn and learning by playing Learners as co-creators of knowledge 	-
Santally et al., 2019	<ul style="list-style-type: none"> Type of publication: Qualitative explorative study Number of living labs: 1 Domains: education living lab (courses in gerontology) Subject of innovation: age-friendly services and products Aim: gain insight into experiences of participants in living lab 	<ul style="list-style-type: none"> Definition: In an educational setting, a living lab enables different stakeholders, including driven innovation A living lab aims to develop and create high-quality, creative innovations that answer the needs and aspirations of a particular group of end-users. Key elements: Applied research and innovation based on co-creation, real world context and impact, partnerships, user involvement 	<ul style="list-style-type: none"> Model: Appreciative inquiry principles - Openness, Continuity Approach: Co-creation approach 	<ul style="list-style-type: none"> Context: Two Dutch Universities, Educational setting Stakeholders: faculty, retired faculty providers, researchers, healthcare organizations, and members of local businesses Roles: - Students - different roles: project leader, data collector and analyst, and presenter Other adults: providers of insights, support and advice, some cases mentors and trainers. Governance: - 	<ul style="list-style-type: none"> Lessons learned: - Finding the right balance between freedom and invest time in building relationships between co-creators (successfactor) - Maintaining equality in co-creation (successfactor) - Tension between what is beneficial for a user-driven living lab and what is appropriate for an educational system (challenge) - Right balance between distance and proximity (challenge) - Paradox: inconvenient, but shared feeling of insecurity → shared responsibility 	<ul style="list-style-type: none"> Five core competencies: - identifying and formalization of age-friendly services; - applying knowledge of the ageing process; - co-creation, connecting and cooperating; - identifying and utilizing opportunities; - professionalization. 	<ul style="list-style-type: none"> Four projects = student assignments doing research with rather than on others 	-
van den Berg et al., 2019	<ul style="list-style-type: none"> Type of publication: Knowledge synthesis and qualitative analysis Number of living labs: 1 (6 courses) Domains: Sustainability Subject of innovation: embedding education in real world living labs Aim: use a social practice perspective to map out the interrelations between RvL and higher education. 	<ul style="list-style-type: none"> Definition: Real-world Lab (RvL): institutionalized interfaces between science and society. A framework to address goals relating to research, practice, and education. Transformative approach and goals that are socially legitimated, commonly used, and oriented towards the community good. Urban transition lab: hybrid, flexible and transdisciplinary platform that provides space and time for learning, reflection, and development of alternative solutions. Urban Living Lab: Framework for co-creation, but in a rather holistic and non-specific way as "urban innovation ecosystems" Learning in a lab: A lab offers a learning environment that is socially legitimated, engaging in a real-world issue, the lab supports cyclical learning processes that combine different forms of learning. Key elements: Research-orientation Normativity Transdisciplinarity Transformative approach Inclusion of civil society generation Living Lab character 	<ul style="list-style-type: none"> Model: Social practice theory offers a medium scale understanding of social interaction and change. Approach: From typical management and structural perspectives to a user oriented perspective → learning-oriented activity can be embedded. 	<ul style="list-style-type: none"> Context: real-world environment city district Oostdatt Stakeholders: experts, co-designers, facilitators, teachers Roles: - The RvL and its team contribute from the beginning (t); both the RvL and the transdisciplinary skills of students are part of the overall skills. - Practice partners (b) contribute mainly in terms of images, primarily in phase III. - Students (c) are not part of the process in phase I, mostly receptive in phase II and only some remain active in phase III. - Contributions take place almost only in III-IV. They contribute images throughout, use their skills during phase IV. In some cases, the results presented are "stuff", but not always. Governance: - 	<ul style="list-style-type: none"> Lessons Learned: - Phase I. Preparation - Beginning - Phase II. Introduction: Sustainability and Transdisciplinarity as Key Images on Tap in a RvL - Phase III. Proposal: Skills and Images on Tap in a RvL - Phase IV. Project Work: All in the Hands of Students - Phase V. Results: Presenting to the Right Audience - Phase VI. Phase-Out: Various Activities: Call for Flexible Action. 	<ul style="list-style-type: none"> Images have a high relevance throughout the process, least so in the phase-out. The relevance of skills increases in the project with the presentation of the results, a major shift in the style of working together that needs to be managed carefully. Stuff plays a minor role in the process, but rarely drops out completely Networks have highest importance at the beginning and the end 	<ul style="list-style-type: none"> Phase I. Preparation Phase II. Introduction: Proposal Phase III. Project work Phase IV. Results Phase V. Phase-Out 	-
van den Berg et al., 2007	<ul style="list-style-type: none"> Type of publication: qualitative evaluation Number of living labs discussed: 1 Domains: Occupational Therapy Education Subject of innovation: educational methods 	<ul style="list-style-type: none"> Definition: Moving the traditional on campus lab to a community site requiring the students to work with clients currently receiving occupational therapy services. Key elements: - 	<ul style="list-style-type: none"> Model: - Approach: - 	<ul style="list-style-type: none"> Context: Community sites with client receiving occupational therapy services - private school for children with disabilities Stakeholders: students, children with disabilities, instructors, Classroom staff, lab assistant Roles: - 	<ul style="list-style-type: none"> Lessons learned: - Establishment of a community site that was willing and able to accommodate a group of students (Challenge) - Insurance and increased accountability (challenge) - Logistical barriers (challenge) - Immediately apply theoretical concepts discussed in labs in real situations 	<ul style="list-style-type: none"> To apply theories in a therapeutic setting increase professional development and clinical reasoning 	<ul style="list-style-type: none"> See and undergo first what students learn on paper and in class Lab assignment 	-

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education Learning outcomes	Teaching and self-study methods	Examination methods
	<p>• Aim: qualitative evaluation of teaching-learning experience during a living lab.</p> <p>Type of publication: knowledge synthesis Number of living labs discussed: 2 Domain: Industrial design Subject of innovation: New technologies – networks of interaction Aim: present mechanism to facilitate expertise and community building in living labs</p>	<p>• Definitions: - • Key elements: - reflection and action are essential elements - Identity building - Expertise building - Community building</p>	<p>• Model: Transformative theoretical framework essential for education (future designers) • Approach: Meaning is created in interaction (ecological theory of perception and phenomenology)</p>	<p>Students → roles changed weekly: peer observers, group leaders Staff observers → instructors, lab assistant, OT staff from school • Governance: - • Context: Industrial design department • Stakeholders: students, staff, clients (industry, commerce, non-profit organisations), government and users • Roles: Different participants all have their role within the theme: initiator (Camp), partner, link, supplier, or user • Governance: -</p>	<p>• Lessons learned: - Organization that supports the construct – unconstruct – reconstruct process (success factor) - Attitude of lifelong learning (success factor) - Infrastructure that supports information sharing and collaboration between the different stakeholders - Close collaboration in projects is a powerful mechanism to learn and to understand each other and to benefit from each other's expertise (success factor) - It is essential that themes cover different areas of expertise, include coaches from our different capacity groups and include design practitioners and experts from industry (success factor). - Participants are invited to speak each other's language (challenge) - Close cooperation in projects (challenge) - Integration of research and education (challenge)</p>	<p>Students need to develop the ability to reflect, to self-regulate their learning, to take responsibility, to learn from experience and to assess themselves.</p>	<p>• Attitude plays an important role • Students create own individual curriculum • Staff members shift from teacher-focused to learning-focused • Learning is being an authentic source of knowledge to facilitating students' learning. • During and at the conclusion of learning activities, students reflect on their activities, and they invite staff members involved to provide them with (written) feedback on their learning experiences. • Learn by doing • Reciprocal relationship between thinking and doing/making</p>	<p>Showcase at the end of semester 4 exhibitions per year</p>
Hurnits & Vinke. (2010).	<p>• Type of publication: Knowledge synthesis • Number of living labs discussed: 1 (2 examples) • Domain: ICT • Subject of innovation: ICT Living Labs for Education • Aim: application of vision of sign-making society to education in an ICT living lab</p>	<p>• Definition: A living lab (LL) is both a real and virtual environment for user-centred innovation, based on the observation of every-day user practice and experience for solving problems, but also based on their active participation, with an approach that is user-centred and distributed. • Design: It engages all concerned partners in the real-life contexts and aims to create sustainable usage values. • Key elements: 4P innovation process – Public-Private Partnership with People First step: ideation Second step: co-design Third step: formalize a solution</p>	<p>• Model: Sign-based society • Approach: 3D tetrahedon model → The Living Lab stands at the centre of the tetrahedon for communication purpose and ICT is fuelling the convergence of Research, Education and Business with a new signification process.</p>	<p>• Context: Real educational context – Creativity platform = co-working, co-learning, and communication space (physical and virtual) • Stakeholders: Public and private actors, companies, associations, individual • Roles: - • Governance: -</p>	<p>• Lessons learned: - The need to facilitate the creation and maintenance of new content on the platform (challenge)</p>	<p>-</p>	<p>• Game-based learning • Edutainment • Tool → IKBS platform (Iterative Knowledge Base System), ISBS • Teachers and learners can play together to share their interpretations of observations</p>	<p>Assessments of future e-services are made by considering the usage side of the project: end-users have their own identities, activities, tasks and give meaning to the obtained results</p>
Corryr et al. (2014)	<p>• Type of publication: in depth research, case studies and grounded theory • Number of living labs discussed: 1 • Domain: Higher education • Subject of innovation: Living labs for Knowledge management • Aim: present a framework for Knowledge Management processes and using social media tools in a living lab environment</p>	<p>• Definition: LLs are environments for collaborative innovation and discovering knowledge. One of the main objectives of a LL is to use knowledge for further innovation. The general objective of a LL is to be a real-life collaborative development platform. LL is a tool organisations use within a cloud. They make integration, collaboration, and knowledge management possible. • Key elements/principles: - Knowledge objects: any artefacts that knowledge seekers could use to learn, or expand their current knowledge about a topic - Open innovation and co-creation are core activities and processes</p>	<p>• Model: Knowledge management • Approach: LL as a thinking an rethinking support environment - systems thinking - multidisciplinary and collective intelligence thinking - critical thinking - performance thinking - process thinking</p>	<p>• Context: web enabled living lab • Stakeholders: end users, researchers, industrialists, and policy makers • Roles: - • Governance: -</p>	<p>• Lessons learned: - control the various thinking processes and to manage the subsequent processes to ensure manageable deliverables (success factor) - Include social media tools, web 2.0 technologies (success factor) - Work smarter, not harder (success factor)</p>	<p>-</p>	<p>• Knowledge objects (KO) are any artefacts that knowledge seekers could use to learn, or expand their current knowledge, about a topic. Variety of formats, ranging from digital media to web 2.0 objects. • Web 2.0 technologies (social media tools)</p>	<p>-</p>
De Jager et al., 2012	<p>• Type of publication: in depth research, case studies and grounded theory • Number of living labs discussed: 1 • Domain: Higher education • Subject of innovation: Living labs for Knowledge management • Aim: present a framework for Knowledge Management processes and using social media tools in a living lab environment</p>	<p>• Definition: LLs are environments for collaborative innovation and discovering knowledge. One of the main objectives of a LL is to use knowledge for further innovation. The general objective of a LL is to be a real-life collaborative development platform. LL is a tool organisations use within a cloud. They make integration, collaboration, and knowledge management possible. • Key elements/principles: - Knowledge objects: any artefacts that knowledge seekers could use to learn, or expand their current knowledge about a topic - Open innovation and co-creation are core activities and processes</p>	<p>• Model: Knowledge management • Approach: LL as a thinking an rethinking support environment - systems thinking - multidisciplinary and collective intelligence thinking - critical thinking - performance thinking - process thinking</p>	<p>• Context: web enabled living lab • Stakeholders: end users, researchers, industrialists, and policy makers • Roles: - • Governance: -</p>	<p>• Lessons learned: - control the various thinking processes and to manage the subsequent processes to ensure manageable deliverables (success factor) - Include social media tools, web 2.0 technologies (success factor) - Work smarter, not harder (success factor)</p>	<p>-</p>	<p>• Knowledge objects (KO) are any artefacts that knowledge seekers could use to learn, or expand their current knowledge, about a topic. Variety of formats, ranging from digital media to web 2.0 objects. • Web 2.0 technologies (social media tools)</p>	<p>-</p>

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Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education Learning outcomes	Teaching and self-study methods	Examination methods
Evans et al., 2015	<ul style="list-style-type: none"> Type of publication: Knowledge synthesis Number of Living Labs discussed: 1 campus as living lab, more living lab projects Domain: sustainability Subject of innovation: applied Aim: identifying the strengths of the living lab approach and the challenges of applying it more broadly 	<ul style="list-style-type: none"> Definition: IPT Urban Europe defines living labs as: "a forum for innovating... [and] the development of new products, systems, services, and processes, employing working methods to integrate people into the entire development process as users and co-developers" Key elements: <ul style="list-style-type: none"> processes, systems, concepts and creative solutions in complex and real contexts" Cycle: develop, test, implement and evaluate space Geographically or institutionally bounded Conduct experiments that make social and/or material alterations Appropriate an explicit element of iterative learning 	<ul style="list-style-type: none"> Model: - Approach: - The Manchester Method: working with non-academic stakeholders to develop real-world skills Systems approach 	<ul style="list-style-type: none"> Context: University of Manchester Campus Stakeholders: researchers, students, external stakeholders (NGOs, SMEs), environmental consultants, university estates and facilities staff. Roles: Students in the role of planning Governance:- 	<ul style="list-style-type: none"> Lessons learned: <ul style="list-style-type: none"> Living labs have the potential to strategically frame coproduction processes in two ways. <ul style="list-style-type: none"> consulting users and stakeholders allows complementary sets of projects to be strategically planned that offer holistic solutions emphasising the iterative process of experimenting and learning from year to year they provide a more coherent basis for action over time. Bridging the divide between the social sciences and physical sciences (challenge) Parcelling the opportunities into manageable projects that can be executed in the short-term using resources available in the university Linking projects to real life challenges for design and construction (challenge) 	<ul style="list-style-type: none"> Teaching purpose: <ol style="list-style-type: none"> students must see themselves as the target user group students must see themselves as the market pioneer students must see themselves as operators 	<ul style="list-style-type: none"> Net positive: a tool an online questionnaire about their interaction with the institution and the city, students receive constructive advice on how they can reduce their carbon footprint Sustainability exercise 	-
Peng et al., 2010	<ul style="list-style-type: none"> Type of publication: Evaluation study Number of living labs discussed: 1 Domain: Telekom operation and management teaching Subject of innovation: Living lab as experiential learning environment Subject of application of the technology innovation model concept of living lab to the construction of the experiential learning environment 	<ul style="list-style-type: none"> Definition: Massachusetts Institute of Technology of United States in 1995: As a response to the opportunities and challenges of information society and knowledge society, Living Lab runs on city-wide open experimental space, provides a condition and environment for users to participate easily and voluntarily in designing innovative solutions. It makes it easier for operators who live and work in cities, provides real-time prototype design and test platform for innovative applications. Key elements: <ul style="list-style-type: none"> Experiential learning circle model, 4 iterative stages: <ul style="list-style-type: none"> concrete experience reflective observation abstract conceptualization active experimentation 4-point circular pattern: <ul style="list-style-type: none"> theoretical research the development of products and services the practical application of testing the commercial promotion 	<ul style="list-style-type: none"> Model: Living Lab Model proposed by Massachusetts Institute of Technology → Technology innovation model Approach: <ul style="list-style-type: none"> Experiential Teaching → student centred, students' dominant position during teaching process Based on: <ul style="list-style-type: none"> Dewey's experience philosophy Levin's experiential learning development theory Levin's experiential learning model 	<ul style="list-style-type: none"> Context: a human machine interactive environment Stakeholders: education, various types of users who live and work in cities Roles: - Governance:- 	<ul style="list-style-type: none"> Lessons Learned:- 	<ul style="list-style-type: none"> Teaching purpose: <ol style="list-style-type: none"> students must see themselves as the target user group students must see themselves as the market pioneer students must see themselves as operators 	<ul style="list-style-type: none"> Experiential teaching: variety of scenarios to guide students to experience the educational scenario from passive to active, from dependence to independence, from acceptance to creativity, and learn to avoid, deal with, and overcome negative emotions and the wrong understandings, learn to develop, enjoy and use of positive emotions and the right awareness, to enable students to fully experience the joy and pleasure stored in the teaching activities, so as to achieve the purposes of the promotion of students' self-development. Four iterative stages (Cooper): <ul style="list-style-type: none"> concrete experience reflective observation abstraction mobile applications 	-
Peng et al., 2010	<ul style="list-style-type: none"> Type of publication: Literature review, survey, and interview study Number of Living Labs: Lab General Education Seminar → 30 participating departments Domain: Place based learning (PBL) Subject of innovation: Living lab as pedagogical model in PBL Aim: to study the influence of place-based learning activities (in LL) and perceived levels of student engagement. 	<ul style="list-style-type: none"> Definition: A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting. An emerging public-private partnership (PPP) concept in which firms, public authorities and citizens work together to create, prototype, validate and test new technologies in real-life contexts, such as cities, city regions, rural areas, and collaborative virtual networks between public and private players. 	<ul style="list-style-type: none"> Model: Pedagogical model of the living lab → broad access to high quality technological and professional education for a diverse urban population Approach: experiential learning, social – experiencing, reflecting, thinking, and acting 	<ul style="list-style-type: none"> Context: 30 academic departments Stakeholders: students, teachers, field seminar, in the first semester of the take the role of learner Governance:- 	<ul style="list-style-type: none"> Lessons Learned:- 	<ul style="list-style-type: none"> Discipline specific and general education learning outcomes 	<ul style="list-style-type: none"> Include PBL as part of their teaching practice Workshops, presentations, shared readings, field visits. Includes PBL in their assignments 	-
Goodlad & Leonard, 2018	<ul style="list-style-type: none"> Type of publication: case study analysis Number of living labs: 2 living labs Domain: Field of information systems Subject of innovation: the role of Living labs in facilitating and enabling designed serendipity, two case studies in the field of information systems (IS) Aim: analysis of the causal mechanisms and critical factors that contribute to serendipity designed within the context of the cases evaluated and within platform design. 	<ul style="list-style-type: none"> Definition: A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting. An emerging public-private partnership (PPP) concept in which firms, public authorities and citizens work together to create, prototype, validate and test new technologies in real-life contexts, such as cities, city regions, rural areas, and collaborative virtual networks between public and private players. 	<ul style="list-style-type: none"> Model: Critical Realism has been viewed as an approach that can play a role in advancing the development of IS knowledge through Design Research. Critical Realism proposes a focus on causal mechanisms and what researchers call generative mechanisms. Approach: Co-design process where students and staff 	<ul style="list-style-type: none"> Context: digital platforms (African context) Stakeholders: higher education Roles: - Governance:- 	<ul style="list-style-type: none"> Lessons learned: <ul style="list-style-type: none"> Occurrence of Serendipity (I) unexpectedness, (II) insightfulness, and (III) value (success factor) The mechanisms, methods and techniques of the LL approach seem to offer potential in terms of empowering users to increase the involvement in the innovation process (Challenge) Involving users in the innovation process These elements of a successful platform: <ul style="list-style-type: none"> Connection 	<ul style="list-style-type: none"> Living Lab Design Approach 	<ul style="list-style-type: none"> Living Lab Design Approach 	-
Groop, 2018	<ul style="list-style-type: none"> Type of publication: Literature review, survey, and interview study Number of Living Labs: Lab General Education Seminar → 30 participating departments Domain: Place based learning (PBL) Subject of innovation: Living lab as pedagogical model in PBL Aim: to study the influence of place-based learning activities (in LL) and perceived levels of student engagement. 	<ul style="list-style-type: none"> Definition: A Living Lab is a design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting. An emerging public-private partnership (PPP) concept in which firms, public authorities and citizens work together to create, prototype, validate and test new technologies in real-life contexts, such as cities, city regions, rural areas, and collaborative virtual networks between public and private players. 	<ul style="list-style-type: none"> Model: Pedagogical model of the living lab → broad access to high quality technological and professional education for a diverse urban population Approach: experiential learning, social – experiencing, reflecting, thinking, and acting 	<ul style="list-style-type: none"> Context: 30 academic departments Stakeholders: students, teachers, field seminar, in the first semester of the take the role of learner Governance:- 	<ul style="list-style-type: none"> Lessons Learned:- 	<ul style="list-style-type: none"> Discipline specific and general education learning outcomes 	<ul style="list-style-type: none"> Include PBL as part of their teaching practice Workshops, presentations, shared readings, field visits. Includes PBL in their assignments 	-

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Hansen, 2017	<ul style="list-style-type: none"> Type of publication: Effectiveness study Number of living labs discussed: 1 (from living laboratory academics projects) Domain: Sustainability education Subject of innovation: Education for sustainable development Aim: effectiveness of one living laboratory case study at Macalester College in St. Paul, Minnesota, USA 	<ul style="list-style-type: none"> Key elements: <ol style="list-style-type: none"> contextualization concretization implementation feedback and evaluation Definition: <ul style="list-style-type: none"> Using the campus buildings and grounds as explicit educational tools for sustainability education Using new education buildings as living laboratories is relatively common in the architecture field multidisciplinary learning Applied research Practical work 	<ul style="list-style-type: none"> Model: Service learning → combination of community service and academic learning Community volunteer projects as part of educational experience. Approach: - 	<ul style="list-style-type: none"> Context: Living Laboratory Campus Stakeholders: students, macalester college, environmental studies faculty, industry, staff, sustainability manager Roles: - Students that actively participate Governance: - 	<ul style="list-style-type: none"> Gravity Flow <ul style="list-style-type: none"> Lessons learned: Eight elements to building a living lab <ol style="list-style-type: none"> Engage the right campus participants ID key collegiate programs Build credibility through engagement and data Integrate into curriculum Expand beyond individual program of study Build partnerships with industry Engage support beyond campus Communicate Continue to seek out industry and faculty support Look for ways to engage with other departments Actively engage upper administration to highlight the results of the living laboratory projects Look for ways to link the campus living lab projects with the work already underway in the community Expand on current interdisciplinary projects to incorporate other disciplines, not currently working within the LL program 	<ul style="list-style-type: none"> Adding key sustainable design elements into teaching and learning Participatory methods that empower learners to change their behaviour and act for sustainable development Teaching classes 	<ul style="list-style-type: none"> Less competitive pressure 	
Hank et al., 2012	<ul style="list-style-type: none"> Type of publication: Knowledge synthesis Number of living labs discussed: 1 (Lurako Living Lab) Domain: service business development Subject of innovation: service and experience design, service development Context: living laboratory, living lab, institutions in tourism, and the creative and well-being sector. Aim: the relationship between the LLs and a variety of stakeholders is discussed 	<ul style="list-style-type: none"> Definition: A living lab should be seen as a research concept and is user centred. It is often linked to, or operates in, a city or a region, and frequently involves communities, not as observers but as participants – as a source of creation. Living labs aim at creators and users of innovative concepts. In LLs, research is focused on capturing evidence and data from end-users involved in the LL case. LLs encourage users and developers to work very closely together and the evidence from “real life” testing is used to improve the resulting products and services. Key elements: - 	<ul style="list-style-type: none"> Model: - Approach: Nordic countries believe in a flat leadership style as being the most effective model for encouraging the growth and sustainability of living labs. 	<ul style="list-style-type: none"> Context: Lurako Living Lab, city district Stakeholders: universities, businesses, organizations, researchers, government entities, community members, and customer end-users Roles: students collaborate with stakeholders, instructors are mentors to students, more equal relationship between professors/instructor and students. Students are at the core of any relevant learning experience, and effective leadership in education may often have fundamental impact on these experiences. Leaders should be able to handle tension and problems effectively in an unpredictable setting. 	<ul style="list-style-type: none"> Lessons learned: <ul style="list-style-type: none"> Living labs based on win-win mentality (success factor) Less competitive pressure (success factor) Flat leadership (success factor) 	<ul style="list-style-type: none"> Depending on the goal and content of the LL, specific students from relevant disciplines are chosen to participate. 	<ul style="list-style-type: none"> Provide relevant opportunities for real learning experiences for students as well as for community stakeholders 	<ul style="list-style-type: none"> Less competitive pressure
Gualandri & Romme, 2019	<ul style="list-style-type: none"> Type of publication: case description Number of living labs discussed: 3 cases (Stratemeind Living Lab, Amsterdam Field Labs, Textile & Clothing Living Lab) Domain: Engineering Subject of innovation: Realisation of different kinds of value Aim: to develop a framework of various funding options which can be employed by any LL that seeks to become more financially sustainable 	<ul style="list-style-type: none"> Definition: The so-called Living Lab (LL) is an emergent methodology that can be instrumental in bridging the gap between new technologies developed in corporate or university research labs and the actual adoption of (products and services based on) these technologies by users Key elements: exploration, co-creation, experimentation, and evaluation 	<ul style="list-style-type: none"> Model: According to ENELL (2016), LLs are “user-centered, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real-life communities and settings”. Approach: - 	<ul style="list-style-type: none"> Context: urban environments Stakeholders: public administration, education institutes, companies, and citizens. Roles: - Governance: - 	<ul style="list-style-type: none"> Lessons Learned: <ul style="list-style-type: none"> Each LL should define its optimal funding mix, with the following guidelines in mind: <ul style="list-style-type: none"> The LL should explicitly distinguish between strategic and project partners The LL needs to explicitly classify the kind of value created Funding can be generated from the stakeholder-partners in the LL, but also from external actors Research funding (to be) acquired is linked to the nature and modality of the LL Public and private funding are very different in nature and modality and tend to imply fundamentally different requirements and expectations. 	<ul style="list-style-type: none"> Lessons Learned: <ul style="list-style-type: none"> The LL should explicitly distinguish between strategic and project partners The LL needs to explicitly classify the kind of value created Funding can be generated from the stakeholder-partners in the LL, but also from external actors Research funding (to be) acquired is linked to the nature and modality of the LL Public and private funding are very different in nature and modality and tend to imply fundamentally different requirements and expectations. 	<ul style="list-style-type: none"> Lessons Learned: <ul style="list-style-type: none"> The LL should explicitly distinguish between strategic and project partners The LL needs to explicitly classify the kind of value created Funding can be generated from the stakeholder-partners in the LL, but also from external actors Research funding (to be) acquired is linked to the nature and modality of the LL Public and private funding are very different in nature and modality and tend to imply fundamentally different requirements and expectations. 	<ul style="list-style-type: none"> Less competitive pressure

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Juerna et al. 2017	<ul style="list-style-type: none"> Type of publication: Combination knowledge synthesis and qualitative evaluation study Number of Living Labs: 1 living lab: Living Lab Applied Gerontology Domain: Applied Gerontology Design: Applied Gerontology Aim: to nurture intrinsic motivation: need for competence, need for a sense of relatedness. Subject of innovation: development and implementation of age-friendly services and the design of a powerful learning environment Aim: to present the design of a powerful learning environment and to discuss its value for nurturing the students' intrinsic motivation for co-creation based on focusgroup 	<ul style="list-style-type: none"> Definition: - Key elements/principles: Real life contexts Five successive phases: Define, discover, dream, design, destiny Aim to nurture intrinsic motivation: need for competence, need for a sense of relatedness. 	<ul style="list-style-type: none"> Model: - Approach: based on the principles of appreciative inquiry, design thinking and self-determination theory 	<ul style="list-style-type: none"> Context: realistic powerful learning environment applied gerontology – neighbourhood Stakeholders: Companies, adults, gerontologists Students – autonomy/freedom, older adults – asked the students critical questions and taught them to see and experience the world from a different perspective Governance: - 	<ul style="list-style-type: none"> Lessons learned: - Balance freedom – structure (Successfactor) Importance of interest shown by the lecturer (successfactor) Realistic learning task essential for intrinsic motivation (Successfactor) Age-friendly services to be bigger than impact of lecturers (Successfactor) A learning environment that includes older adults as partners in realistic learning tasks for gerontology students is essential in nurturing students' intrinsic motivation to develop competencies in cocreation. 	<ul style="list-style-type: none"> The degree to which students develop competencies is determined by their intrinsic motivation. To train gerontologists as age-friendly services in the cocreation of age-friendly services (innovativeness and collaboration) Competence levels of cocreation: - Competent level Advanced beginner Novice level 	-	-
Juerna et al. 2017	<ul style="list-style-type: none"> Type of publication: literature review and case descriptions Number of Living Labs discussed: 5 Domain: sustainable tourism research, education, and practice Subject of innovation: living labs in relation to education, innovation, and sustainable tourism Aim: explore sustainable tourism in relation to the concept of student living labs 	<ul style="list-style-type: none"> Definition: Student living labs, defined as spaces for open innovation, co-creation, and experimentation in real-life settings with students. Key elements: Open innovation, Co-creation, Experimentation 	<ul style="list-style-type: none"> Model: Massachusetts Institute of Technology (MIT) – The group integrated design and technology approaches to improve cities' resource efficiency and responsiveness to inhabitants needs and desires Approach: Design approach/design thinking, user-centred design, co-design, user-centred design 	<ul style="list-style-type: none"> Context: LLs mainly act in a defined context such as a city or a region. Stakeholders: Triple, quadruple or penta helix model for stakeholder involvement often used Master's students, municipality, idea-based sector, residents, local business, ex-students, start-ups, business coaches, creative industry businesses, international research knowledge centre, local organizations, experts in each discipline Roles: Living labs can be hosted by universities, public authorities, or private sector organisations. Lecturers are mentors who listen and advice rather than set directions (flat leadership) Governance: - 	<ul style="list-style-type: none"> Lessons learned: - Importance of 'neutral' spaces for living labs (successfactor). Closeness between firms and end-users, drives innovation (success factor) An essential point of departure for co-creation is learning (success factor) Project timelines (challenge) Equality among participants (challenge) The size of the student groups (challenge) The resources of the university (challenge) 	<ul style="list-style-type: none"> An experiential approach goes in line with the change of emphasis based on the Bologna declaration for education, focusing on learning outcomes and competences through meeting the needs of the labour market (challenge) and a transition from a teaching to a learning approach 	<ul style="list-style-type: none"> case studies → opportunities and challenges of a real-world setting → collaborate with other stakeholders, Active, participatory learning means emotional involvement or commitment Conversation, feedback, and critical reflection Using an experimental approach, the students navigate in the social situation of working with others, reflect on their own learning and enrich the educational outcomes continuum of experiential co-created learning theories, approaches, styles, and methods 	<ul style="list-style-type: none"> Real life research questions Space for user with the entire cycle of user analysis, design, prototyping and user studies Projects/assignments
Jernsand, 2019	<ul style="list-style-type: none"> Type of publication: Knowledge synthesis, case descriptions and evaluation Number of living labs discussed: 3 Domain: ambient intelligence Subject of innovation: library 2.0 services, monitoring ADL in assisted living apartments, interactive wall in psychiatric ward of nursing home Aim: present the way that the living labs are implemented in its educational program and share lessons learned 	<ul style="list-style-type: none"> Definition: A new way of innovating requires a new research methodology that enables co-creation, early testing, and iterative evaluation in real-world settings – the living lab methodology. An approach that represents a user-centric methodology for sensing, prototyping, validating, and refining complex solutions in evolving real life contexts. Key elements: - Approach: - Involved in research & design solutions A setting that exposes users to novel (ICT) solutions A (semi) realistic context Suitable for long-term experiments A place for the evaluation of new developments as well as for the discovery of new possibilities 	<ul style="list-style-type: none"> Model: The living lab methodology (MIT) Approach: - 	<ul style="list-style-type: none"> Context: public spaces and health lab (2 locations) Stakeholders: Lecturers, Students, Researchers, Companies, End users, Technology providers and System designers Roles: - Governance: - 	<ul style="list-style-type: none"> Lessons learned: - Engage the stakeholders Take care of sufficient technical support Improve the student skillset Embedding in the school calendar Evaluation of the student work Students learn to do research hands on Use multidisciplinary groups Interdisciplinary approach needs some extra support from the supervisors in the beginning 	<ul style="list-style-type: none"> Courses with creativity and innovation as its core elements Conducting practical and applied research Improvement and innovation of the professional practice 	<ul style="list-style-type: none"> Real life research questions Space for user with the entire cycle of user analysis, design, prototyping and user studies Projects/assignments 	<ul style="list-style-type: none"> General educational and research activities regarding to a huge number of diverse activities regarding teaching and learning as well as research and innovation at an university campus Specific Living Lab teaching formats regarding innovative approaches to sustainability education
Kröse et al. 2012	<ul style="list-style-type: none"> Type of publication: case description Number of living labs discussed: 1 Subject of innovation: living labs in education for Sustainable development, focus renewable energies (in higher education) Aim: highlight the importance of living labs as innovation infrastructures in the higher education en presents the specific education experience 	<ul style="list-style-type: none"> Definition: The concept of Living Lab LOW3 is implemented in research, innovation, derived from the definition of living labs, as well as the co-creation and open innovation in real-life settings through a multi stakeholder approach (academia, companies, and research entities but also local administration), understanding both the "users" of this newly generated platform. Key elements: - 	<ul style="list-style-type: none"> Model: Concept of user involvement in research and innovation Approach: - 	<ul style="list-style-type: none"> Context: solar house living lab for sustainable architecture, companies, and research entities but also local administration Roles: Stakeholders can participate in a community of users beyond established academic structures, with transversality from high school students up to senior researchers. Governance: - 	<ul style="list-style-type: none"> Lessons learned: - Immediate relation to the daily life of people (success factor) 	<ul style="list-style-type: none"> Social awareness Generic SD competencies Specific knowledge Specific SD competences Innovation 	<ul style="list-style-type: none"> General educational and research activities regarding to a huge number of diverse activities regarding teaching and learning as well as research and innovation at an university campus Specific Living Lab teaching formats regarding innovative approaches to sustainability education 	<ul style="list-style-type: none"> General educational and research activities regarding to a huge number of diverse activities regarding teaching and learning as well as research and innovation at an university campus Specific Living Lab teaching formats regarding innovative approaches to sustainability education
Massek, 2017	<ul style="list-style-type: none"> Type of publication: case description Number of living labs discussed: 1 Subject of innovation: living labs in education for Sustainable development, focus renewable energies (in higher education) Aim: highlight the importance of living labs as innovation infrastructures in the higher education en presents the specific education experience 	<ul style="list-style-type: none"> Definition: The concept of Living Lab LOW3 is implemented in research, innovation, derived from the definition of living labs, as well as the co-creation and open innovation in real-life settings through a multi stakeholder approach (academia, companies, and research entities but also local administration), understanding both the "users" of this newly generated platform. Key elements: - 	<ul style="list-style-type: none"> Model: Concept of user involvement in research and innovation Approach: - 	<ul style="list-style-type: none"> Context: solar house living lab for sustainable architecture, companies, and research entities but also local administration Roles: Stakeholders can participate in a community of users beyond established academic structures, with transversality from high school students up to senior researchers. Governance: - 	<ul style="list-style-type: none"> Lessons learned: - Immediate relation to the daily life of people (success factor) 	<ul style="list-style-type: none"> Social awareness Generic SD competencies Specific knowledge Specific SD competences Innovation 	<ul style="list-style-type: none"> General educational and research activities regarding to a huge number of diverse activities regarding teaching and learning as well as research and innovation at an university campus Specific Living Lab teaching formats regarding innovative approaches to sustainability education 	<ul style="list-style-type: none"> General educational and research activities regarding to a huge number of diverse activities regarding teaching and learning as well as research and innovation at an university campus Specific Living Lab teaching formats regarding innovative approaches to sustainability education

A Closer Look at Living Labs and Higher Education using a Scoping Review

Renée van den Heuvel, Susy Braun, Manon de Bruin & Ramon Daniëls

Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education Learning outcomes	Teaching and self-study methods	Examination methods
McCormick & Kiss, 2015	<p>Type of publication: case description and evaluation of living labs discussed: 1</p> <p>Domain: diverse real-time learning environments in a local context</p> <p>Subject of innovation: learning environments</p> <p>Aim: investigates the relevant hands-on challenges creating a supportive learning environment when projects in sustainable urban renewal are used for educational activities</p>	<p>Definition: In this study we define a hybrid living lab as a learning environment situated at the interface of school and workplace in which working and learning are integrated. Learning is typically trans-boundary in nature and it is embedded in ill-structured, authentic tasks such as assignments for real-life clients or other stakeholders in the community.</p> <p>Key elements: -</p>	<p>Model: Malmö Innovation Platform (MIP): brings together stakeholders and community actors to build a joint innovation capacity in the renovation of existing apartment buildings.</p> <p>Approach: -</p>	<p>Context: Local/urban context</p> <p>Stakeholders: Students, Stakeholders</p> <p>Roles: Students and teachers often enter the scene as equal; teachers often serve as facilitators for learning by providing useful frameworks, enabling access to experts, and guiding reflection, and due to the innovative nature of projects also co-learning with students</p> <p>Governance: -</p>	<p>Lessons learned:</p> <ul style="list-style-type: none"> Many positive impacts for the MIP: students, teachers, and stakeholders The assessment of the intended learning outcomes (challenge) Undefined and constantly changing nature of innovation and 'experimental' sustainability projects (challenge) Economic push and policy support are weak (challenge) 	<ul style="list-style-type: none"> Evaluation exercises (learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching) Role-play debate (learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching) Reflection seminars (learning-by-researching) 	<ul style="list-style-type: none"> Monitoring energy consumption Measuring water consumption Measuring waste production Assessing indoor comfort Reporting about food habits Calculating the overall ecological footprint of the inhabitants 	<ul style="list-style-type: none"> Learning processes and the 'study approaches' reported for describing the extent of learning outcomes have been achieved. Assessment is integral in the interactions of teaching and learning. Reflection seminars, group discussions and course evaluations → qualitative assessment of learning outcomes
Mc Cormick et al., 2014	<p>Type of publication: knowledge synthesis</p> <p>Number of living labs discussed: 1</p> <p>Domain: ICT and human computer interaction</p> <p>Subject of innovation: education/innovative teaching (living lab)</p> <p>Aim: discusses and outlines the elements of Living Labs, and how these have played a role in the establishment of a new Education Living Lab</p>	<p>Definition: Environments, a methodology or an approach which caters for user-driven open innovation within real-life rural and urban contexts, where users can collaborate with multiple or multiple stakeholders in one or more locations, to become co-creators or co-designers of innovative ideas, processes, or products within multidisciplinary environments.</p> <p>Key elements:</p> <ul style="list-style-type: none"> Is driven by Users; Involves: Real-life communities and multiple stakeholders; Is user-driven on: Collaboration and co-creation as well as an innovation; Is aimed at: Multi-disciplinary open innovation; 	<p>Model: Living Lab paradigm is applied to act as a catalyst to address complex challenges in education, such as the Digital Divide of Schools</p> <p>Technology's (DST) Vision for ICT innovation</p> <p>The Living Lab paradigm creates inter-disciplinary spaces where participants or stakeholders can co-create solutions to challenges.</p> <p>Approach:</p> <p>The living lab can be both an environment as well as an innovation</p> <p>The idea of 'open innovation' in one of the core principles</p>	<p>Context: hybrid learning configuration of applied sciences in the Netherlands.</p> <p>Stakeholders: students (different study programmes, different levels).</p> <p>Roles: -</p> <p>Governance: -</p>	<p>Lessons learned:</p> <ul style="list-style-type: none"> Stakeholders to engage in two or more cycles of self-directed lifelong learning Provide educational support consisting of instruction, a professional profile and feedback Pay attention to emotional and motivational aspects Treat self-directed lifelong learning as a social learning process Set learning goals and results from early in the learning process Provide an atmosphere of safety and trust Position self-directed lifelong learning as a self-evident, integrated part of the course. Involve all lecturers and assistant-coaches in the process of self-directed lifelong learning. 	<ul style="list-style-type: none"> Students vary in prior knowledge and ambitions. Although they all aim to master similar professional tasks, each student encounters their own challenges and must learn from them in the process. 	<p>Workshops and a study guide</p>	<ul style="list-style-type: none"> Progress reports Self-assessment Future driven self-assessment
Cremers & Herselman, 2015	<p>Type of publication: Knowledge synthesis</p> <p>Number of living labs discussed: 1</p> <p>Domain: ICT and human computer interaction</p> <p>Subject of innovation: education/innovative teaching (living lab)</p> <p>Aim: discusses and outlines the elements of Living Labs, and how these have played a role in the establishment of a new Education Living Lab</p>	<p>Definition: Environments, a methodology or an approach which caters for user-driven open innovation within real-life rural and urban contexts, where users can collaborate with multiple or multiple stakeholders in one or more locations, to become co-creators or co-designers of innovative ideas, processes, or products within multidisciplinary environments.</p> <p>Key elements:</p> <ul style="list-style-type: none"> Is driven by Users; Involves: Real-life communities and multiple stakeholders; Is user-driven on: Collaboration and co-creation as well as an innovation; Is aimed at: Multi-disciplinary open innovation; 	<p>Model: Living Lab paradigm is applied to act as a catalyst to address complex challenges in education, such as the Digital Divide of Schools</p> <p>Technology's (DST) Vision for ICT innovation</p> <p>The Living Lab paradigm creates inter-disciplinary spaces where participants or stakeholders can co-create solutions to challenges.</p> <p>Approach:</p> <p>The living lab can be both an environment as well as an innovation</p> <p>The idea of 'open innovation' in one of the core principles</p>	<p>Context: academic department</p> <p>Stakeholders: academia, industry, students and other stakeholders, different sectors (public and private), communities, researchers, public entities, private companies, individuals, communities of practice, other LIs;</p> <p>Roles: -</p> <p>Governance: -</p>	<p>Lessons learned:</p> <ul style="list-style-type: none"> Co-creation of a commonly owned vision (success factor) Strong leadership (success factor) Self-responsible from inception (success factor) A strong sense of challenges and the ability to be nimble and responsive to stakeholder needs (success factor) Regular face-to-face interactions (success factor) Hosting or co-locating the LL network within an existing strong organization (success factor) Support for sustainability (success factor) 	<ul style="list-style-type: none"> Students vary in prior knowledge and ambitions. Although they all aim to master similar professional tasks, each student encounters their own challenges and must learn from them in the process. 	<p>Workshops and a study guide</p>	<ul style="list-style-type: none"> Progress reports Self-assessment Future driven self-assessment
Callaghan & Herselman, 2015	<p>Type of publication: case description and evaluation of living labs discussed: 1</p> <p>Domain: diverse real-time learning environments in a local context</p> <p>Subject of innovation: learning environments</p> <p>Aim: investigates the relevant hands-on challenges creating a supportive learning environment when projects in sustainable urban renewal are used for educational activities</p>	<p>Definition: In this study we define a hybrid living lab as a learning environment situated at the interface of school and workplace in which working and learning are integrated. Learning is typically trans-boundary in nature and it is embedded in ill-structured, authentic tasks such as assignments for real-life clients or other stakeholders in the community.</p> <p>Key elements: -</p>	<p>Model: Malmö Innovation Platform (MIP): brings together stakeholders and community actors to build a joint innovation capacity in the renovation of existing apartment buildings.</p> <p>Approach: -</p>	<p>Context: Local/urban context</p> <p>Stakeholders: Students, Stakeholders</p> <p>Roles: Students and teachers often enter the scene as equal; teachers often serve as facilitators for learning by providing useful frameworks, enabling access to experts, and guiding reflection, and due to the innovative nature of projects also co-learning with students</p> <p>Governance: -</p>	<p>Lessons learned:</p> <ul style="list-style-type: none"> Many positive impacts for the MIP: students, teachers, and stakeholders The assessment of the intended learning outcomes (challenge) Undefined and constantly changing nature of innovation and 'experimental' sustainability projects (challenge) Economic push and policy support are weak (challenge) 	<ul style="list-style-type: none"> Evaluation exercises (learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching) Role-play debate (learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching, learning-by-researching) Reflection seminars (learning-by-researching) 	<ul style="list-style-type: none"> Monitoring energy consumption Measuring water consumption Measuring waste production Assessing indoor comfort Reporting about food habits Calculating the overall ecological footprint of the inhabitants 	<ul style="list-style-type: none"> Learning processes and the 'study approaches' reported for describing the extent of learning outcomes have been achieved. Assessment is integral in the interactions of teaching and learning. Reflection seminars, group discussions and course evaluations → qualitative assessment of learning outcomes
Ref	1. Article information	2. Living Lab definition(s) and key elements	3. Theoretical model/ approach	4. Living lab context	5. Lessons learned	6. Education Learning outcomes	Teaching and self-study methods	Examination methods

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Røhnebæk and Francesco Mureddu

“ Alone, we go faster. Together, we go further. ”

Motto of the Living Lab of Foch Hospital,
Suresnes (Paris), France

Living labs have gained increased attention in research and practice as both a practical and theoretical innovation phenomenon that emphasizes co-creation, real-life settings, and user/customer involvement. More recently, living labs have also emerged as a specific approach to open innovation processes in the context of publics across the EU. Nevertheless, it is still not clear how the understanding of living labs can be translated and organized into new sectorial settings, what type of public sector innovation challenges it addresses, and what role citizens and users have. The aim of this article is therefore to explore and analyze how living labs are applied as processes for public sector innovation. Based on a mixed method approach of 21 European living lab cases, the analysis reveals a pattern of three different processes for living lab organizational and actor roles: living labs organized as cross-sectorial collaboration, living labs emerging within the public sector as main initiator and beneficiary, and living labs developed by civil society actors. The findings are presented as three scenarios for implementing living labs, which also acts as a background for the article's final discussion about the potentials and pitfalls of living labs in public sector contexts.

Introduction

The acknowledged move from traditional public administration (TPA), over to new public management (NPM), then to the current shift towards new public governance (NPG) has spurred an increased awareness on the role of external stakeholders in developing public services, and hence the way public sector innovation takes place (Hartley, 2005; Torfing, 2019). Public sector innovation is now more dependent on joint processes based on cross-sectorial collaboration, which implies that public innovation has become complex and dynamic, since citizens multifaceted needs require several actors to coordinate their efforts. Innovation therefore now takes place in a complex multi-actor context of politicians, policymakers, public managers, employees, users, citizens, civil actors, and private firms.

A platform and methodology for such innovation processes are living labs (Leminen et al., 2012; Ruijter & Meijer, 2020). Living labs are defined as collaborative environments for experimentation in and of real-life contexts (Gascó, 2017). Living labs are still, however, somewhat underexplored in the context of public sector innovation, herein how they are organized and with what they contribute (Schuurman & Tõnurist, 2017; Hansen & Fuglsang, 2020).

Therefore, to better understand and learn from existing living labs, the main aim of this article is to investigate and analyze how living labs spur and enact processes of public sector innovation in a European context, and to discuss the potentials and pitfalls of living labs as a way of doing public sector innovation. This leads to the following two research questions: *a) How are living labs*

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalaari Röhnebak, & Francesco Mureddu

applied to engage actors in public sector innovation processes?, and b) What promises do such innovation processes hold?

The research is based on a mixed methods design, encompassing 21 case studies of living labs across nine EU countries (Fuglsang & Hansen, 2021; 2022) and a thorough survey of co-creation methods in the public sector, distributed to public managers in six EU countries (Arundel & Es-Sadki, 2021). The paper extends previous research on the societal framing of living labs (Ruijter & Meijer 2020; Fuglsang & Hansen, 2022), and involving methods used in living labs, by presenting experiences from cases of how living labs can organize public sector innovation processes in terms of various scenarios.

The article is structured as follows: first, a short overview of the theory base is presented, followed by an introduction to the methodology applied. Subsequently, key analytical results are accounted for and discussed. Finally, concluding remarks are given, and future research avenues proposed.

Theory Base

Public sector innovation

Innovation as concept may take slightly different meanings across various sectors and research traditions. Yet, most of the literature maintains that innovation encompasses the two intertwined processes of creating something new, and implementing this new creation in practice (Torfing 2019; Fuglsang & Hansen, 2022). The processes that lead to innovation are summarized in terms of, for example, structures and stages of innovation, specific drivers that lead to innovation, such as entrepreneurs or R&D, specific procedures such as design processes, and certain innovation roles. While much emphasis is on the structures and stages of innovation processes, some authors have also conceptualized innovation as a practice-based inherently incremental activity (Fuglsang, 2010), that is, as integrated with work and organizational routines. The practice-based approach is especially evident in innovation processes taking place within everyday work in public service delivery leading to the creation of new knowledge and new behaviors (Fuglsang, 2021).

The acknowledgement of contextual factors has led to the argument that it is important to develop relevant and restricted concepts for public sector innovation

(Gault, 2018). Windrum (2008) proposed a useful distinction between six types of innovation found in the public sector: service innovation, service delivery innovation, administrative and organizational innovation, conceptual innovation, policy innovation, and systemic innovation. Hartley (2005) added governance innovation as a special feature of public sector innovation. Governance innovation refers to new forms of citizen engagement in innovation, and rhetoric innovation, which means new language and concepts in a service domain. Hartley also suggested that rather than speaking of types of innovation, such as radical and incremental, governance or rhetorical, it may be more correct to treat innovation, particularly complex innovations, as multidimensional processes since the different types are connected in practice (Hartley, 2005).

Besides the focus on how and with what innovation contributes, innovation processes in a public sector context, especially in settings with a high degree of citizen-employee encounters, is based on the logic of open, co-creational and collaborative innovation (Hartley et al., 2013; Voorberg et al., 2015). Open innovation describes how the knowledge of citizens and other actors external to government organizations is included (Fuglsang, 2008). Resulting from this openness, the knowledge that is created can be heterogeneous in its nature and might also result in beneficial outcomes for the organization due to, for example, organizational learning and increased innovation capability (Mergel, 2015). Co-creation designates processes of co-initiation, co-design and co-implementation of public services with citizens and users (which encompasses both citizens as users and employees) (Voorberg et al., 2015). These characteristics are especially evident in the application of living labs.

Living labs as processes for public sector innovation

The term “living lab” or “innovation lab” stems from information and communication technology (Eriksson et al., 2005; Nesti, 2017; Fuglsang et al., 2021), where it emerged as a phenomenon, and practice, that supported test environments either as lab facilities or as facilities in real-life settings. From the outset, living labs have therefore been platforms for collaboration processes between developers and users. Later, as the use of living labs spread and the approach became conceptualized within an open innovation paradigm, more layers were introduced. Gascó (2017), based on Schaffers and Turkama (2012) defined living labs in a public sector context as:

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

“settings or environments for open innovation, which offer a collaborative platform for research, development, and experimentation in real-life contexts, based on specific methodologies and tools, and implemented through specific innovation projects and community-building activities” (Gascó, 2017).

Many current living labs refer back to such forms as quadruple (or even quintuple) helix innovation processes (Hakkarainen & Hyysalo, 2014; Baccarne et al., 2016), that engage actors across sectors and from multiple angles of innovation (Tõnurist et al., 2017). Also, living labs are perceived as strategic, structured and deliberate processes of innovation initiated by a primary actor.

At the beginning of the millennium, the living labs phenomenon appeared in the public sector to ensure interactive innovation processes with a distinct focus on employees and/or citizens. The focus on living labs in public sector contexts was also reinforced by founding the European Network of Living Labs (ENoLL), under the Finnish Presidency of the Council of The European Union in 2006. Living labs differ from other open innovation approaches as they are platforms for experimentation, wherein participants, for example, representatives from private sector organizations, the public sector, universities, users, and citizens meet in person to develop innovations together. Thus, the aspect of place/space often matters at the outset as a trigger for doing innovation, since living labs are developing various new workplace practices and services with a goal of channelling innovative knowledge and routines for innovation acquisition into host organizations (Fuglsang & Hansen, 2022). As such the notion of living lab also supports the acknowledged governance shift towards New Public Governance (NPG) (Dekker et al., 2020; Criado et al., 2021). Consequently, the concept’s extension has led to an on-going discussion about living labs as much more than just an instrument or method; as living labs are also perceived as an innovation methodology, or certain mindset within which to potentially frame both new and existing understandings and practices (Dell’Era & Landoni, 2014; McGann et al., 2018). Thus, the application and introduction of living labs in the public sector might itself be seen as a trigger for more inclusive innovation processes alongside increased awareness that gives employees and citizens an active role in development. Living labs are therefore on the one hand seen as an

opportunity to include heterogeneous knowledge from different actors to solve problems, but on the other hand the outcome of such processes and the role of the users and citizens are still not very clear (Hansen & Fuglsang, 2020).

Methodology

To study how living labs are applied as processes for public sector innovation, a multiple case study (Yin, 2014) was conducted to gain insights on how different constructions of living labs appear in different public sector contexts, and by whom they are initiated. Our case study draws together insights from qualitative and quantitative data collected in 2018 and 2019 (see Fuglsang & Hansen, 2022). All data stems from the EU funded project “Co-VAL”, that is seeking new paths to co-creation of value in order to transform public administration services and processes.

The qualitative data are based on 21 in-depth case studies across nine EU-countries, conducted by the authors of the article. Based on an extensive literature review on living labs in a public sector context (Fuglsang & Hansen, 2019), the following sample criteria were chosen:

1. Public service characteristics: large-scale services (digitalization, supporting citizen welfare broadly), or “small-batch” services (public administration, elderly care).
2. Sectors/actors: public organized (state level/municipal department), civil society (citizens/non-profit organizations), or private (company/entrepreneurs).
3. Form of organization: formalized/less formalized, and/or networked/single organization.
4. Temporality: initiatives targeting here-and-now challenges, or initiatives targeting long-term challenges. Temporality in this context is related to the notion of public value. Thus, here-and-now refers to current challenges to specific citizen/user groups, while long-term refers to challenges encompassing future generations.

This led to a final sample of the following 21 cases (Fuglsang and Hansen, 2021; 2022) presented in Table 1.

We used a shared case study protocol to guide the

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

Table 1. Overview of cases and data material per country

Case	Case-country	Sector/ ownership	Type of public service/ temporal aspect	Data material
IDES Living lab	Spain	NGO	Mental health care/ here-and-now	1 group interview with managers One-day field study
Guadalinfo	Spain	Public	Digitalization/long-term	1 group interview with managers and with front-end employees One-day field study
Library Urban Lab	Spain	Partnership model: academia & municipality	Digitalization/ long-term	1 in-depth interview with manager One-day field study
Living lab of the ministry of economy and finance	Italy	Public - central level	Digitalization/ here-and-now	1 in-depth interview with public senior manager 1 in-depth interview with stakeholders Field visit
The Rome Heritage Lab	Italy	Public	Cultural heritage/long-term	1 in-depth interviews with public manager Field visit
PWC Experience Center	Italy	Private	Citizen welfare/ here-and-now	1 interview with senior manager 1 interview with stakeholder Field visit
Torino City Lab	Italy	Public - regional/state level	Citizen welfare/ here-and-now	Semi-structured interviews with senior managers, policy makers and front-line staff (11 in total) Field visit
GovLab Austria	Austria	Public – federal level	Public administration/long-term	3 in-depth interviews with senior managers 1 in-depth interview with external user
GovLab Arnsberg	Germany	Public – regional/state level	Public administration/long-term	3 in-depth interviews with senior managers 7 in-depth interviews with board members
Verschwörhaus Ulm	Germany	Public – local government level	Digitalization/ here-and-now	4 in-depth interviews with public managers 4 in-depth interviews with volunteers
Wallonia e-health Living Lab	Belgium	Public – relying partly on EU funding	Digitalization/ long-term	1 in-depth interview director 4 in-depth interviews with managers 1 in-depth interview with a project leader 1 in-depth interview with an external key stakeholder Field visit
INSP	Denmark	NGO	Citizen welfare/long-term	2 in-depth interviews with senior managers 3 in-depth interviews with employees 1 in-depth interview with external collaborator Four days of participant observation
Public Intelligence	Denmark	Private	Health care/long-term	3 in-depth interviews with managers 1 in-depth interview with strategic partner Field visit
Aalborg Municipality	Denmark	Public - local government level	Elderly care/ here-and-now	3 in-depth interviews with public managers 2 in-depth interviews with external collaborators Field visit
StimuLab	Norway	Public	Citizen welfare/ here-and-now	3 in-depth interviews with public managers 2 in-depth interviews with policy makers Field visit
Norwegian Labour and Welfare administration	Norway	Public	Public administration/long-term	2 in-depth interviews with top-level strategic manager at directorate level 3 in-depth interviews with managers/designers 1 in-depth interview with local manager 4 interviews with frontline employees in a local NAV office
L.I.V.E.	France	Public	Public administration/long-term	4 in-depth interviews with public managers 3 in-depth interviews with external collaborators Observations of 3 workshops
SIILAB	France	Public	Digitalization/ here-and-now	3 in-depth interviews with public managers 1 in-depth interview with external collaborators 5 interviews with employees Observations of 2 workshops
AUTONOM'LAB	France	Public	Elderly and disabled care/ here-and-now	1 in-depth interview with director/public manager 5 in-depth interviews with employees 1 in-depth interview with the former director manager Observation of 1 workshop
ERASME	France	Public	Digitalization/long-term	2 in-depth interviews with public managers
Kraków Living Lab	Poland	PPP	Citizen welfare/ here-and-now	4 in-depth interviews with policy makers 5 in-depth interviews with person responsible for initiatives Field visit

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

research across cases. Concerning the unique case contexts, the protocol allowed for adaptations so that the most suitable strategies for data collection could be used. The data collection strategy was based on data triangulation, by a combination of document studies, semi-structured interviews, and observations, with various weightings. Afterwards, the data was subjected to a cross-case analysis, focusing on how each case adds to and reveals insights regarding the overall unit of analysis: *living labs in the context of public sector innovation*.

In addition to the empirical case studies, we extracted quantitative data concerning co-creation in the context of design firms, innovation labs, and living labs from a comprehensive European survey on co-creation and public sector innovation (Arundel & Es-Sadki, 2021). The overall aim of the survey intended to estimate the prevalence of co-creation methods in the innovation activities of public sector organizations, factors that influence the use of co-creation, obstacles to the use of co-creation, and the effect of co-creation on innovation activities and outcomes.

The survey followed a detailed protocol where the first stage (“pre-survey preparations”), implied the delivery of the questionnaire (paper mail) to 1125 managers in France, Spain, the UK, Hungary, the Netherlands, and Norway. The second stage (“survey implementation”), was conducted over 4 or 5 months in 2019, where 3497 questionnaires in total were sent out (also offering an online survey option), and 1036 total replies obtained,

which means a total response rate of 32.7%. The respondents were public administration middle or senior managers representing three geographical levels: small municipalities 32%, large municipalities 32%, and central-state national administrations 33% from different sectors such as health, education, and central public services.

To analyze the specific survey results concerning user contributions to innovation integrated into this paper’s case study, we used a multinomial logit model to reveal: 1) prevalent co-creation methods, 2) main barriers to spur user contributions to innovation, and, 3) drivers of user contributions based on various sources of demand. The question about co-creation methods was asked following a categorical yes/no/don’t-not know response.

Findings

The analysis dives into the role of living labs in promoting users’ involvement in co-creation and innovation processes, while also identifying a pattern of three different approaches to establishing living labs in a public sector context. In the next section, key analytical findings are presented together with offering three scenarios for establishing future living labs.

Different approaches to living lab organizing

Our analysis of the 21 case studies revealed three processes of living labs as experimental settings organized to address public and societal challenges through engaging external stakeholders, especially

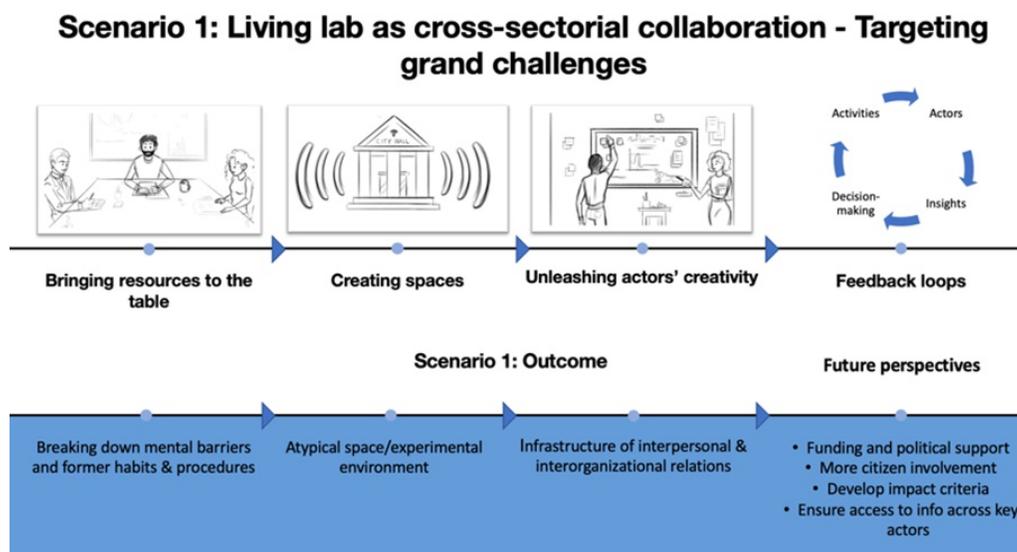


Figure 1. Living lab as cross-sectorial collaboration

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

citizens. Also, it became apparent that the propensity of different institutional levels to use living labs partly depend on the types of challenges to address, as well as the degree of stakeholder engagement needed. These findings are summarized in the form of three fictive scenarios. Scenarios used as method are both a way to present a huge amount of data and a tool to be applied in different development phases to review and analyze potential aspects of establishing a living lab (Stickdorn & Schneider, 2011). The scenarios are based on recurring features observed during the case study research, placed alongside theoretical knowledge (Fuglsang & Hansen, 2021); hence they do not exist strictly as presented, yet are to be read as illustrations of key findings and insights from the research.

Scenario 1: Living labs for “grand” challenges

Living labs can structure innovation processes for addressing challenges to society at large - not only in a here and now context, but also for future generations. Living labs for such “grand societal challenges” address major unsolved problems of education, inequality, climate, digitalization, unemployment, and social heritage. These types of living labs are often organized as cross-sectorial networks based on shared “ownership”, and hence they might be positioned either in or outside a formal public sector organization. Users are involved at various stages to help set priorities for challenges and test innovations at an early stage. In cases relevant to this scenario, living labs stress the engagement of actors in a new way of

thinking about innovation in the public sector. Also, the creation of a more experimental and inclusive approach to stakeholder engagement leads to a more elaborated and qualitatively stronger network of interpersonal and inter-organizational relations. Regarding future points to give attention, especially the need for funding and political support, reaching beyond project periods was a key concern among informants. This is also linked to a lack of qualitative impact criteria such that relationship-building and networks established become part of the success parameters for organizing living labs. Lastly, an on-going discussion continues about the degree of citizen involvement, since most cases expressed a wish for and urge to give citizens an even more decisive role.

Cases representing Scenario 1 included: Public Intelligence, PWC Experience Center, Kraków Living Lab, GovLab Austria, ERASME, Torino City Lab, and Guadalinfo.

Scenario 2: Living labs for domain specific challenges

Living labs can be organized to address challenges relative to specific public service services and welfare. In this scenario, they are often positioned within the public sector, and while cross-sectorial collaboration is encouraged, the main decision-making power lies with public managers. Moreover, these types of living labs often have public sector employees as either their sole target group, or as important a target group as citizens. Hence, users are the service recipients, and they are involved through using design approaches, such as

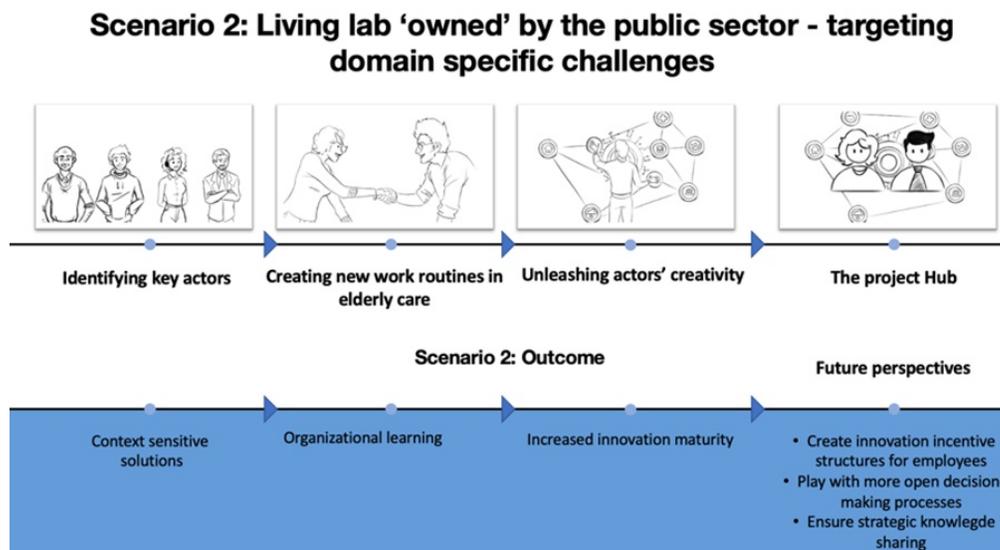


Figure 2. Living lab “owned” by the public sector

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalaari Röhnebak, & Francesco Mureddu

observation and interviewing.

In cases relative to this scenario targeting specific domain challenges, living lab activities lead to solutions that are close to the context in which they are to be practiced. Consequently, the aspects of organizational learning and increased innovation maturity were highlighted by informants to stress that not only a specific outcome, but also the innovation process itself is very valuable. Therefore, there was an articulated need for incentive structures that spur innovation and the innovation capabilities of employees in the public sector. Knowledge sharing across public sector departments and institutions was also a concern to make sure innovation practices and experiences are diffused. Finally, there was among actors a curiosity towards expanding the existing “limits” of user and citizen involvement relative to decision-making, since employees and managers self-critically reflected if the current existing limits are based on legal concerns, or instead primarily cultural and mental barriers.

Cases representing Scenario 2 included: Aalborg Municipality, AUTONOM’LAB, Stimulab, Norwegian Labour and Welfare administration, SIILAB, Living lab of the ministry of economy and finance, GovLab Arnsberg, Wallonia e-health Living Lab, and L.I.V.E.

Scenario 3: Living labs as citizen-led initiatives targeting public value

Living labs can be initiated or led by citizens to identify and address societal challenges, which might reach beyond specific public welfare services. These types of living lab initiatives are often depicted by a strong civil society engagement and collaborate mainly with the public sector to partly ensure funding. As such, they seem to enact an explicit urging within European public sectors to openly engage citizens in developing innovative public services and creating public value. Hence, it seems relevant to better understand how the public sector might support such bottom-up initiatives, where citizens are engaged as both initiators and users of the activities taking place within the framework of a living lab.

The experiences from citizen-led living labs show that the openness towards outcome creates a platform, whereby other actors than the ones initially thought of as beneficiaries get attracted. As such, the living lab ends up offering place/space for the wider public, thus implicating that explicit actor roles become less important, while the boundary between these is diminished. By showcasing that such new ways of collaboration can function, living labs seem to expand and trigger a change in administrative procedures when cooperating with the public sector. The future potential of these citizen-led living labs may rely on getting municipalities to play along, such that evaluation criteria that mirrors the reality of these initiatives may be developed.

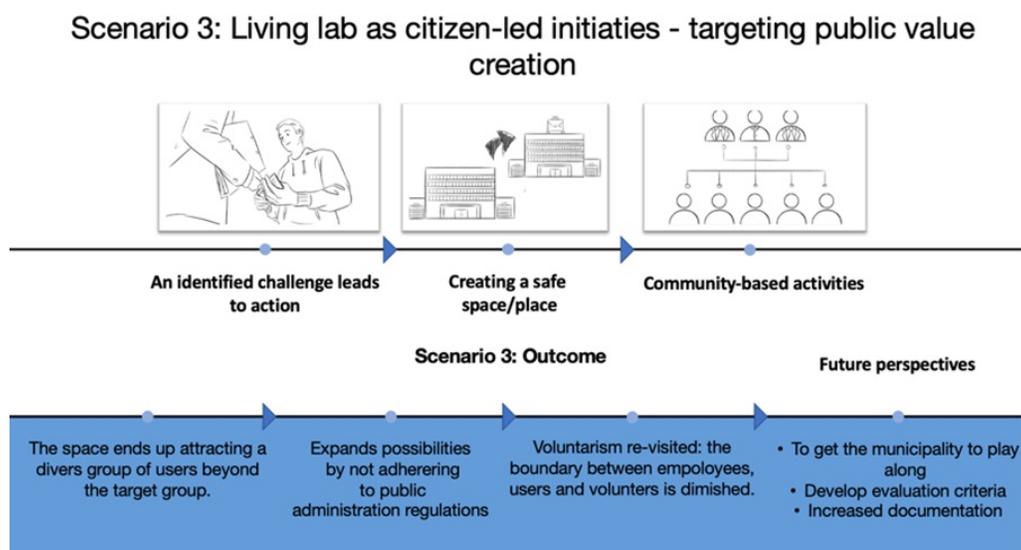


Figure 3. Living lab as citizen-led initiatives Figure

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalaari Röhnebak, & Francesco Mureddu

Cases representing Scenario 3 included: Verschwörhaus Ulm, INSP, IDES Living lab, Rome Cooperative Heritage Lab, and Library Urban Lab.

The aspect of co-creation in living lab practices

Across the identified different approaches to living labs, they all engage stakeholders, including users, in developing public services. The results of the multinomial logit carried out (Table 2), support this result, and moreover adds insights on the interplay between co-creation methods and innovation potential. The model shows that all the co-creation methodologies investigated (analysis of user data, conversations with users, focus groups, brainstorming, and prototyping) are statistically significant regarding relevancy of the final outcome of innovation processes taking place in the context of innovation or living labs. Citizens and other stakeholders may be engaged through direct and indirect participation, yet the more active and direct forms (for example, brainstorming with users), the more significant. In addition, the case

study analysis indicated that how stakeholders are involved depends on who leads the initiative. Except users in citizen-led living labs, it seems difficult to mobilize stakeholders for the whole innovation process. Users are mainly invited to participate in the following stages: upstream in the ideation phase and the rapid prototyping phase, downstream to test prototypes, and in the development phase (further prototyping, tests, returns, and iterations) of innovations that can be implemented in the public sector.

In sum, the quantitative and qualitative findings highlight two key points relative to co-creation: 1) when engaging in or establishing living labs, active user and/or citizen involvement leads to more relevant innovations for the beneficiaries, and, 2) it is key to reflect upon how and where in an innovation process the user and/or citizen are involved, and what the implications are of this involvement in final decision-making processes.

Table 2. Results of the multinomial logit model: users' contributions to innovation

<i>Independent variables</i>	<i>Estimate</i>	<i>Sig.</i>
Control: Country	-0.009	0.812
Control: Level (municipal/national)	0.274	0**
Control: Job level (position)	0.044	0.489
Control: Size of organization	0.021	0.733
Drivers: Demand (from individuals/final users)	0.014	0.779
Drivers: Demand (from external organizations)	0.229	0**
Drivers: Inputs in terms of funding or staff	0.148	0.007**
Living labs assistance	0.369	0.012*
Co-creation methods: User data analysis	0.275	0.016*
Co-creation methods: Conversation with users	0.515	0**
Co-creation methods: Focus groups	0.273	0.023*
Co-creation methods: Brainstorming with users	0.684	0**
Co-creation methods: Prototyping & real-time studies	0.422	0.001**
Barriers: Obstacle to engage users	0.047	0.048*
Barriers: Other obstacles for innovation	0.004	0.773

Notes. The dependent variable is the contribution of users to develop the most important innovation in public sector units. The contributions are ranked according to the level of benefit, distinguishing between “none”, “low”, “medium”, and “high”. With the estimation method using multinomial logit: ** implies 1% significance, * implies 5% significance, † implies 10% significance.

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefogge, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

Discussion

The analytical results highlight how living labs provide support processes for the overall turn towards new interactive and networked forms of governance. In inducing open innovation based on the integration of multiple stakeholders, the focus changes from internal processes towards taking more into consideration how users and citizens are engaged in active and direct co-creation of innovation. But this turn also implies that what is perceived as a success, and to whom, rests on more qualitative parameters, such as, for example, the degree of relation building, the subjective experience of new initiatives and documented organizational learning.

Thus, a concrete challenge of viewing living labs as a public sector innovation method is that the more qualitative aspects, which are the inherent legitimizing factors of living labs, seem to be hard to measure, and hence mainly quantitative performance indicators based on a New Public Management (NPM) logic are typically applied (Ballon et al., 2018; Bronson et al., 2021; Dekker et al., 2021). Moreover, an overall challenge is that the degree of user and/or citizen involvement, which is at the core of living labs, might not be as high as the definition implies. Instead, it seems as if the specificity of living labs is their capacity, and legitimacy, to change the traditional processes of political decision-making processes relative to developing public services (Fuglsang & Hansen, 2022). Thus, living labs are not only a “technology of management”, but also a political choice due to policy makers taking the risk of inviting users into development processes (Olejniczak et al., 2020; Osborne et al., 2020). A pitfall is that organizing public sector innovation as or within living labs does not in and for itself ensure that user and citizens insights and deliberation will be taken seriously by the end of the innovation process (Wegrich, 2019), at least not in the case of living labs, where the public sector itself is, or may be the sole initiator. Also, the living lab approach to open innovation might favour individual concerns and certain “citizen-skills” of engagement. Thus, it could make living labs platforms for certain “voices”, rather than mainly as a democratic outlet for safeguarding “multi-vocality” relative to societal concerns and future public services. Therefore, even though the logic of New Public Governance (NPG) is still prevalent, the instrumental antecedents of the New Public Management (NPM) paradigm may still be apparent: citizens and users are asked to participate in

developing future public services, in innovation processes managed by the public sector, nevertheless, the overall potential of deliberation of what constitutes a fair society based on ideas of the common good might be overlooked (Björgvinsson et al., 2012; Hansen & Fuglsang, 2020).

Concluding Remarks

This research study presented how living labs are used to structure open innovation processes aimed at engaging user perspectives in both the indirect and, especially, direct and active co-creation of innovation. Even though living labs viewed as both a format and methodology can be applied as experiments in stakeholder engagement, the evaluative parameters of what constitutes a successful living lab and living lab activities are still underdeveloped. Nevertheless, living labs as an approach to public sector innovation alters the logic of public governance and supports the transition towards interactive and networked governance (New Public Governance), while at the same time disrupting traditional public sector organizations themselves through stressing extrinsic processes of open innovation, which might serve to ensure a more radical approach to user and citizen involvement (Fuglsang & Hansen, 2022).

Previous research has explored how living labs emerge as niches and bear the potential to frame public innovation in radically new ways by creating foundations for policy actions (Dekker et al., 2020; Ruijter & Meijer, 2020; Fuglsang & Hansen 2022). The research presented here extends this previous research through analyzing and specifying practical scenarios for creating future living labs extracted from empirical cases. Besides the conceptual contribution of these patterns of innovation processes, the research also contributes to practice, since the three scenarios provide inspiration and input for establishing living labs, while also identifying points to pay attention to relative to living labs as a legitimizing construct in engaging external stakeholders in the development of future public services. In continuation hereof, a key concern and managerial implication of the scenarios presented are the relational aspects of driving innovation processes based on an open innovation paradigm. This topic also sets the ground for future research on public innovation, which could benefit from applying a multi-actor scenario perspective on such collaborative processes, also integrating citizen/user perspectives. Lastly, further exploration

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

needs to be done on how innovation processes through the living lab framework described at a micro-level scenario can inform innovation policy at a macro-level, both to document existing practices and also outline future potentials.

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Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Röhnebak, & Francesco Mureddu

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Keywords: Living labs, Public sector innovation, Citizen engagement, Co-creation, Open innovation

Living Labs for Public Sector Innovation: insights from a European case study

Anne Vorre Hansen, Lars Fuglsang, Christine Liefoghe, Luis Rubalcaba, David Gago, Ines Mergel, Nathalie Haug, Maria Taivalsaari Røhnebæk, & Francesco Mureddu

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Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, and Diana Chronéer

“ Don't walk in front of me, I may not follow. Don't walk behind me, I may not lead. Walk beside me and be my friend. ”

Albert Camus

Digital transformation (DT) has received increasing attention in recent years. Up until now, most of the current studies focus on digital transformation in advanced and dense societies, especially urban areas and technologies. Hence, the phenomenon of DT is under-researched in the context of rural and sparsely populated contexts. This study aims at exploring how a rural living lab (RLL) can be shaped and how this approach can be designed to support digital transformation processes in rural contexts. In so doing, following a design science research methodology (DSRM) approach, we have made an artefact (that is, RLL framework) that is an “instantiation” that supports user centric digitalization of rural areas. The designed framework is developed based on the key components of “traditional” and “urban” living labs, as well as empirical data which was collected within the context of the DigiBy project. The DigiBy project aims at conducting DT pilots in rural areas to elevate peoples’ understanding of digitalization and the application of digitalization opportunities for service development in rural areas in the north of Sweden. As a result of these studies, five key components that guide the design of digital transformation pilots in rural areas emerged, namely: 1) rural context, 2) digitalization, 3) governance, control, and business mode, 4) methods facilitating DT processes, and 5) quintuple helix actors. We also offer an empirically derived definition of the rural living lab concept, followed by avenues for future research.

Introduction

Digital transformation (DT) nowadays is changing the dynamics of how societies are shaped (Agarwal, 2020). DT can be understood as the “changes that [the] digital technology causes or influences in all aspects of human life” (Stolterman & Fors, 2004). These changes are visible in different levels and scales, from individual to societal levels, and from more modernized urban areas, like smart cities, to less digitalized rural areas, in which DT occurs in an uncontrolled real-life context, and where people are involved in their everyday use context (Bockshecker et al., 2018; Spagnoli et al., 2019). Since

most studies of the societal effects of digitalization and DT have been carried out in urban areas, there is a dearth of research on the effects of digitalization in rural areas (Salemink et al., 2017; Rotz et al., 2019; Runardotter et al., 2020). Following a participatory design approach, we believe that people have the moral and ethical right to be a part of DT processes (Bansler, 1989; Bjercknes & Bratteteig, 1995), also in rural areas, since digitalization of society can bring enormous (positive and negative) impact in peoples’ lives.

In this paper, we focus on DT and innovation pilots carried out in rural areas, aiming to manage the

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

challenges that emerge in these contexts. The study is supported by a living lab (LL) approach (Bagalkot, 2009; Schaffers et al., 2009; Schuurman, 2015) that has been introduced and proposed as an inclusive and sustainable approach involving various stakeholders, focusing on how individuals in their role as citizens, inhabitants, end-users, etc., are engaged throughout the DT process in their real-life settings (Ståhlbröst, 2008; Bergvall-Kåreborn et al., 2009). Accordingly, LLs can be seen as an approach for facilitating innovation processes, as they allow one to simultaneously focus on individuals, technologies, tasks, and structures, and on the interactions between various stakeholders (Schaffers et al., 2009). To date, most research attention has been paid to urban areas as the context for LL activities, the so-called Urban LL (or ULL) (Steen and Bueren, 2017; Chronéer et al., 2019), for example, the initial list of key components of traditional LLs were further revised and modified for the context of Urban LLs by Chronéer and colleagues (2019).

Nevertheless, few studies have examined the possibilities and potentials of LL activities in relation to rural areas. Most have investigated, for example, one specific dimension such as business models for Rural LLs (RLLs) (Schaffers et al., 2009), co-creation activities and actions in rural context (Bagalkot, 2009), as well as nature-based solutions and sustainability in rural contexts (Zavratnik et al., 2019; Lupp et al., 2021). None that we are aware of have investigated the overall construction of RLLs and their key components. In addition, most studies of LL activities in rural areas have focussed on the context of innovation (Bagalkot, 2009; Saleminck et al., 2017; Rotz et al., 2019) in relation to traditional rural activities such as farming and agriculture. Following that, little attention has been paid about how to design RLL activities, as well as to what constitutes a RLL. This is important for boosting peoples' understanding of LL innovation activities in rural areas, and for building a solid research foundation upon which innovation processes can be built.

One important aspect in relation to the character and philosophy of RLLs compared with ULLs is related to the way they can be interpreted. ULLs are often considered as a context that supports and boosts the development of smart city innovations (Chronéer et al., 2019). In the same vein, RLLs can be seen as an approach that facilitates digital innovation in rural

areas. In addition, ICT and digital innovations in ULLs are relatively mature technology (Saleminck et al., 2017). Meanwhile, in RLLs, digital innovations and ICT infrastructure are less mature, at the so-called fuzzy front-end of innovation (Koen et al., 2001; Takey & Carvalho, 2016).

The aim of this paper is to explore how the LL approach should be designed to support DT pilots distributed in rural areas, while including a diversity of stakeholders. Our point of departure is the five “traditional” key components of LLs, namely, ICT and infrastructure, management, partners and users, research and approach (Bergvall-Kåreborn et al., 2009; Ståhlbröst, 2012). By adopting a “design science” research methodology (Peffer et al., 2007; Gregor & Hevner, 2013), we identify and assess what distinguishes ULL and RLL approaches, and present a framework for RLL DT pilots that contributes to the overall body of research. We also propose a definition for RLL, as well as highlight the key differences and similarities between RLLs and traditional ULLs.

Theoretical Foundation: LLs, Urban LLs and Rural LLs

The need for new approaches to engage various stakeholders and users (rural residents) in the DT process is growing (Evans & Karvonen, 2011). Considering the various consequences of digitalization on peoples' everyday lives (Yoo, 2010; Bockshecker et al., 2018; Baskerville et al., 2019), several reasons exist, such as empowerment and democracy (Boston College et al., 2014) for the acceptance and adoption of digital technologies (Moore, 2019; Padyab et al., 2020). LLs offer an approach to managing innovation activities (Ståhlbröst, 2008; Leminen et al., 2012). Accordingly, LLs facilitate DT, as they emphasize simultaneous focus on technologies, people, tasks, and structures, as well as the interactions between them (Schaffers et al., 2009). LL milieus enable and host digital innovations, usually including five key components: ICT and infrastructure, management, partners and users, research and approach (Ståhlbröst, 2008, 2012; Bergvall-Kåreborn et al., 2009).

As innovations are contextual and situational, various types of LLs have emerged to support innovation processes, for example, with energy efficiency, e-health, human-centred AI, and ULLs (Chronéer et al., 2019). What distinguishes urban from traditional LLs is the

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

focus on the context of innovation with stakeholder and user engagement. However, the distinction between the two is not always clear-cut (Steen & Bueren, 2017).

To identify the key components of ULLs, Chronéer and colleagues (2019) investigated the main differences between traditional LLs and ULLs. They extended the five key components of traditional LLs, and identified seven key components of ULLs, namely:

1. Governance models including management structure, politics, and policies.
2. Financing and business models.
3. Physical representation that takes place in a real-life setting in city contexts.
4. An innovation to experiment with.
5. Partners and end-users (that is, quadruple helix).
6. Approaches for engaging various stakeholders and collecting data.
7. ICT and infrastructure access, such as Internet of things (IoT) devices (Chronéer et al., 2019).

Yet innovation does not solely happen in urban areas. Some examples of studies that have investigated LLs in a rural context, are Guzman and colleagues (2008), who discussed RLLs as an approach for enabling user-driven ICT-based innovation geared towards economic and social development in rural areas. Another example is Zavrtnik et al. (2019), who evaluated the possible contributions of LLs to sustainable rural development and argued that the element of community and social change should be considered as a key element in enabling sustainable living. There have also been attempts to consider RLLs as an experimental milieu where various partners and rural residents develop, implement, and evaluate solutions to address problems that affect their environments (Fleet, 2020). Hence, to date there are no studies that have investigated RLLs from a constructional perspective that aims to define the key components supporting local pilots for DT.

This understanding is of central importance for three

main reasons. First, the aim of a LL approach is to facilitate innovation in various contexts. Thus, the impact thereof needs to be traced and measured. Second, a framework is needed that supports and empowers stakeholders to innovate in rural areas (rural residents, companies, officials). Third, identifying key components will help support a comparable design of distributed innovation activities in rural areas where different stakeholders are engaged in local DT pilots. Designing and evaluating local DT pilots by using the same key components will facilitate knowledge growth and understanding of DT in rural areas. Thus, we argue that a richer understanding of the RLL concept and its various constructions and meanings is needed, which relies on experiences and empirical data from several real-life cases (local pilots) of DT in rural contexts. The real-life cases for our research here were carried out within the realms of a project called “DigiBy”, which will be explained in the next section.

Methodology

This study follows a design science research methodology (DSRM) (Hevner et al., 2004; Peffers et al., 2007). DSRM aims to create an artefact to solve generally ill-defined problems and enables working with socio-technical systems to understand and develop existing structures and processes in an iterative manner (Carlsson et al., 2011). Accordingly, DSRM is known as an appropriate approach that proposes solutions for specific problems in real life settings (Gregor & Hevner, 2013), that is also one of the key principles of all LL activities (Ståhlbröst, 2008; Bergvall-Kåreborn et al., 2009). In this research, DSRM supports the design of the RLL framework, which could be viewed as an “instantiation” (see Hevner et al., 2004), since the framework acts as a “prototype” of a RLL approach and its components, as well as supporting the user-centric digitalization of rural areas. Also, Peffers’ (2007) DSRM followed, which consists of six steps, namely, 1) problem definition, 2) development objectives, 3) artefact development, 4) demonstration, 5) evaluation, and 6) communication.

We collected the empirical data within the context of the “DigiBy” project. The purpose of the project, in collaboration with Luleå University of Technology, the Norrbotten Region and all Norrbotten municipalities in Sweden, was to conduct local DT pilots to increase awareness of digitalization and the application of

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

digitalization opportunities for service development in rural areas. Thus far, the artefact produced has undergone two iterations of the DSRM process. The problem identification phase consisted of (1) exploring and using the theoretical background of the rural situation (Section 3.1) and LLs (Section 3.3), (2) a pre-study period where focus groups were used to determine digitalization needs with village residents and local rural retail coordinators (RRC) in attendance (the results of the pre-study can be seen in Runardotter et al., 2017), and (3) the use of two focus groups and questionnaires about rural digital policies (Section 3.2). These two focus groups consisted of officials at regional and municipal levels, who discussed the rural-urban digital divide and explored what opportunities the participants felt they had to influence rural digital policies, as well as the responsibility they felt to bring rural perspectives into the policy process. These focus groups were conducted with semi-structured

questions (Flick, 2014), and the results made it evident there are two specific groups of officials working with digitalization of rural areas at the regional level in Sweden. Therefore, an online questionnaire was sent out to both these groups to ensure inclusion. The two focus groups were recorded and transcribed, and Critical Systems Heuristics (CSH), a philosophical framework to support reflective practice (Ulrich, 2000), was used to analyse both the two groups and the questionnaire results. The identified problem (end of Section 3.3) was used in setting the development objectives (Section 4). The development objectives were also based on previous studies of the key components of LLs and ULLs (Ståhlbröst, 2008; Bergvall-Kåreborn et al., 2009; Chronéer et al., 2019).

Based on development objectives and the rural situation in northern Sweden, a draft RLL framework was developed. The draft RLL framework was demonstrated

Table 1. DSRM process for designing the Rural LL framework

Iteration	Phase	Method	Objective	Target group	Number of participants	
1st iteration	Problem identification	Pre-study focus groups	Identify needs for digitalization	Rural Residents Local RRC	9	
		2 focus groups	Rural digital divide Rural perspectives in digital policies	Officials at regional and municipal level	9	
		Questionnaire		Two groups of officials working with digitalization of rural areas	29	
	Development objectives	No data collection: the design objectives based on identified problems and the key components of LLs and ULLs				
	Artefact development	ULL Framework used as a basis for the development of the artefact and the pilots				
	Demonstration	RLL pilots	Demonstrate the draft RLL framework	Pilots	14	
	Evaluation	Online workshops and unstructured discussions	Evaluate the draft RLL framework	Pilot leaders	4	
Regional development experts				2		
2nd iteration	Artefact development	4 online workshops	Refine and redesign the RLL framework	Pilot leaders	7	
	Demonstration		Demonstrate and evaluated the revised RLL framework			
	Evaluation					
	Future demonstration and evaluation	RLL pilots				

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

in the projects “Digiby” and “Predictive Movement” with a focus on digitalization of rural areas. In these projects, 14 local pilots were conducted following the first draft of the RLL framework. The researchers met with pilot leaders to ensure their understanding of the framework and to ensure that the framework was implemented consistently throughout all pilots. The pilots then used the draft RLL framework in their planning and evaluation of digital innovations in rural areas. We conducted an online workshop using open-ended questions and unstructured discussions with pilot leaders and regional development experts to evaluate the draft RLL framework. The researchers took notes during both the online workshop and unstructured discussions.

Based on feedback that the draft RLL framework was too comprehensive, complex, and used difficult language, the RLL framework underwent a 2nd design iteration. The entry point of the 2nd iteration was artefact development where 4 online workshops were conducted with the Digby pilot leaders. In each of these workshops, the key components of the RLL framework (rural context and the physical conditions, governance and control, quintuple helix approach, and digitalization) were refined by using simplified language, thus making it easier to follow. Within these workshops the revised framework was demonstrated to and evaluated by the pilot leaders. They saw that the revised framework (explained in Section 4) was still comprehensive, but easier to understand and follow. The next planned step was to further demonstrate and evaluate the revised RLL framework in the pilots. A summary of the methodology can be found in Table 1.

The Rural Situation

Tobler’s (1970) phrase “everything is related to everything else, but near things are more related than distant things” (also called the first law of geography), explains well the difference between urban and rural areas. Despite the vision of “a sustainable digitalized Sweden, where everybody in the whole country is part of and has confidence in the digital society” (Regeringskansliet, 2017), Swedish digitalization policies mainly have an urban focus, where commercial actors are expected to drive the development (for example, neoliberal economic philosophy, see Grimes, 2003; Malecki, 2003). However, commercial initiatives are inevitably profit-

driven, and one way to make profit is to encourage people living close to each other to share costs. Consequently, non-profitable sparsely populated areas become largely dependent on state support (Lindberg, et al., 2021). Moreover, to depend on societal intervention for support becomes problematic in rural areas (Regeringskansliet, 2016). Among others reasons, it often requires collaborations that are not easily achieved between the state, commercial actors, and individuals (Salemink et al., 2017; Cras et al., 2019). As a result, actors in rural areas develop their own solutions, such as village associations, formed by village residents themselves, to cope with things like broadband expansion and digital (extension) services.

To help facilitate the possibility of having a vital and sustainable countryside, great importance is placed on becoming “smarter”, that is, deploying digital technologies and solutions that digitally transform society. DT offers great potentials for the countryside and rural areas in the northern parts of Sweden. By means of digital solutions, we can overcome rural challenges such as geographical distances to potentially ensure that equal opportunities can be reached regardless of where we live (Gillespie et al. 2014). Through the digital economy and remote working conditions, new possibilities for self-employment can increase, which contributes to solving many of the challenges facing rural areas, such as an ageing population, young people leaving, and lack of labour market diversity (Interreg Europe, 2019; Vironen & Kah, 2019). Adding to rural challenges, a discourse analysis of Swedish national policy focusing on rural areas carried out by Rönnblom’s (2014) showed that national policy places the responsibility for rural development primarily in the hands of rural residents themselves. Looking at the urban context there are no similar demands on urban inhabitants (Rönnblom 2014), which leads us to believe that there is need for approaches that strengthen and support rural development by addressing the rural uniqueness and involving the rural inhabitants.

Rural Resilience

Digital policy must take three factors into account to be resilient: It must be multi-scalar (governing collaboration), normative (social and technological factors), and have an integrated approach to resilience (Roberts et al., 2017). Rural digital policies incorporate these factors at a local level, but the expectation of a commercial actor to drive the development is a barrier,

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

since corporate profitability is prioritized before individuals' needs and desires. A triple helix model for implementing digital services and connection in Swedish rural areas exists. Yet the public (rural residents), which is the fourth component in the quadruple helix model, is so far missing in the policy development process (Lindberg, J. et al., 2021).

For instance, in Sweden, 80% of citizens have a fiber connection to their home, yet this coverage is unevenly distributed between urban and rural areas (only 48% in Swedish rural areas). In addition, surface area coverage in Sweden for mobile broadband and mobile telephony is 82% for 10 Mbit/s (2G/3G), whereas the Cellular Coverage index (CCI) shows high inequalities between rural and urban areas (Beek & Reje, 2020).

The Rural Situation

This section outlines the situation of rural areas, based on officials involved in the DigiBy project, in connection to two themes, namely distance and collaboration.

Distance

Regional rural retail plans have an overall vision that rural retail should be available everywhere in Sweden. Everyone should have a grocery store within 10 km and a fuel station within 20 km. These distances are practically impossible to achieve, however, in sparsely populated areas with between 0.2-5 inhabitants per square km, which is common in the four most northern counties in Sweden. The officials there indirectly relate to distance when discussing difficulties of getting support for alternative techniques. For example, many believed that radio technology or 4G LTE would be a solution for connecting rural areas. In 2018, the Swedish Board of Agriculture, responsible for broadband expansion, approved radio links as a Next Generation Access technology (approved for EU-funding). They have not yet, however, approved 4G LTE.

Collaboration

The officials emphasize that collaboration is important from a rural retail perspective. Collaboration between relevant levels would provide a more transparent view of the situation and facilitate decision-making. In addition, collaboration is regarded as a prerequisite for increasing the service level in a rapidly changing society with the argument that work should be

evaluated based on how they collaborate, and how partners experience the situation. One official said: "This is done through a multi-level collaboration locally, municipally and regionally. I believe coordination and collaboration has important intrinsic values, but to increase the commitment, the subject matter must be meaningful in a broader context. Otherwise, cooperation will not become collaboration and co-creation."

Rural Living Lab (RLL) Framework

To facilitate the processes of piloting with digital innovations and DT in rural areas, we developed a framework to support our efforts in the DigiBy project. To ensure that those involved in the project performed their activities in a similar vein, we introduced an Urban LL approach, based on the five key components of traditional LLs (Ståhlbröst, 2008; Bergvall-Kåreborn et al., 2009) and considering the key components from Urban LL (Chronéer et al., 2019) and the interactions with officials.

Taking into consideration the evaluation of the proposed RLL framework, the draft framework was perceived as extensive and unmanageable for a practitioner (that is, pilot leaders). However, in a second design iteration, the pilot leaders were involved in online workshops to redesign the RLL framework, they evaluated the revised framework as still extensive, but used a simpler language, and was easier to understand and follow. They also reasoned that the framework could be divided into parts and used separately for different target groups.

In this article, the endeavour is to adapt the key components (developed to support the design of LL pilot milieus in an urban context) to a rural context where the LL will be more flexible and at the same time streamlined, time-limited and focused on supporting rural DT initiatives. Thus, the RLL framework is for local and distributed pilots with digital innovations in rural contexts and thus facilitate DT. It is not focusing on the innovation processes per se since there are other key principles i.e., openness, realism, value creation, influence, and sustainability (Ståhlbröst, 2012) that should guide these processes in a LL context. As suggested in Peffers et al.'s (2007) DSRM, we design the RLL framework based on the above-mentioned studies of the key components of LLs and Urban LLs approach (Ståhlbröst, 2008; Bergvall-Kåreborn et al., 2009; Chronéer et al., 2019), as well as the empirical data

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

gathered within the context of the DigiBy-project. Considering the presented issues and complexities of DT in rural context, we ended up with the five overarching key components to support the design of RLLs, namely (see Fig. 1):

Each of the key components in the RLL framework are explained in more detail below.

Rural context

The rural context is a key component due to the importance of understanding the specific context of the local DT pilots. For instance, villages depend on governmental support while simultaneously being left to take care of matters themselves. Swedish digital policy follows the prevailing trend that societal digitalization should be carried out and supported by commercial actors. However, in rural areas, with low profitability, low density of inhabitants, village residents initiate digital solutions themselves, for example, associations arrange to dig down fibre cables themselves. Situated conditions must be understood, like status and engagement in local associations, where the local pilot is located, its digital infrastructure (broadband, mobile connection etc), demography of

the local context, companies and relevant public services (for example, schools, post office), who owns the place in which the innovation is to be implemented, plans for the areas (for example, exploitation plans, new natural reserves, changes in laws), and also responsibilities related to the context. In RLL activities, places and spaces that support innovation activities are important to understand and design for (Bergvall-Kåreborn et al., 2015), since all activities should take place in inhabitants' real life with supportive engagement. In the DigiBy project, one of the local DT pilots (digital lock) facilitated an innovative type of collectively-owned grocery store that does not have any employed personnel and is open 24/7 by offering digital and personal logins to the store. Here, the engagement of rural residents in their village association, based on their drive and enthusiasm, were critical to make DT happen. People in the village (both inhabitants and visitors) do not now need to drive 88 kilometres to buy their food, which is good for their economy as well as for the environment.

Governance and business model

Another key component is the governance and business models of sustainable DT on a long-term basis.

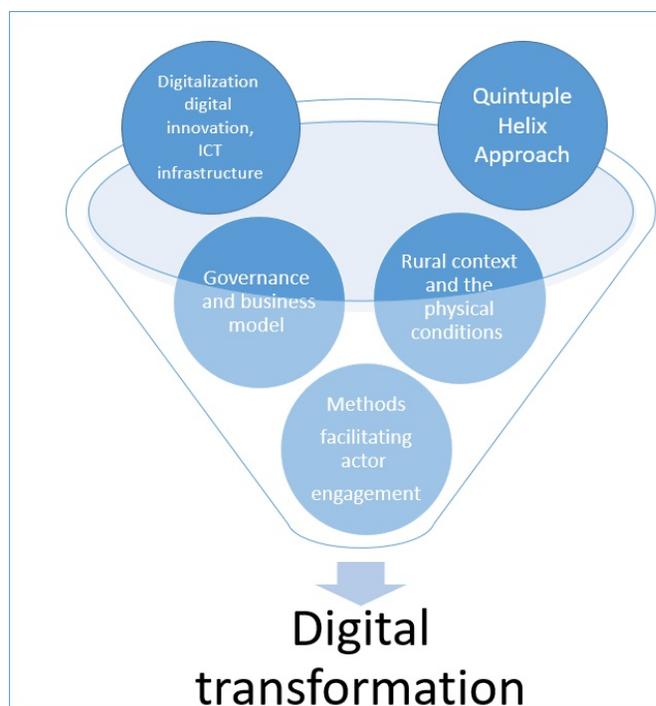


Figure 1. An overview of RLL key components

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

Governance and business models include considering aspects such as risk management, planning for setting up as well as closing a pilot, the spread results of the pilot, keeping track of income/costs, managing material and immaterial resources, working with potential financiers, while also setting up contracts between actors in the RLL. For instance, the ownership of innovation and data, leadership structures and decision making power related to putting content into digital innovations, and thus boosting DT in the countryside. Regarding the business model, it should create, deliver, and capture values for all stakeholders affected by DT. Here it is important to identify value propositions, communication channels, revenue streams, and so forth (Osterwalder & Pigneur, 2010).

As in ULLs, local governments and decision makers have a prominent role in the facilitation of RLLs, for example, sharing experiences between various local initiatives so that learning and opportunities can emerge in other locations. For instance, in the DigiBy-project, officials with the role of rural developers shared our project findings with other villages in their municipalities. Further, DT initiators in the municipalities had contact with each other and the researchers. These rural developers have good local and people knowledge, that is, they know the people running various rural initiatives, and they have ongoing communication with them. In the rural context, being able to live and make business locally is of utmost importance. For instance, introducing ICT can lead to the creation and development of new BM areas (new potential revenue streams), and also be an enabler of various types of innovations, and thus businesses. As an example, in the DigiBy project, information screens were implemented in a local grocery store, which made it possible for local companies to post ads that all visitors in the store could see. This created a new revenue stream for the local grocery store, as well as new business opportunities for the local company.

Methods facilitating actor engagement

The methods used support planning and carrying out data-collection in the local pilots, as well as knowledge sharing between the many actors involved in local initiatives. The methods aim to encourage active engagement within and between local pilot sites, rural residents, researchers, and government throughout the

entire DT processes. The FormIT methodology (Ståhlbröst, 2008) has been developed to support LL innovation processes, emphasizing the inclusion of external sources of knowledge and ideas in exploration, creation, implementation, and evaluation of concepts, together with prototypes and innovations in real-life settings, which is of utmost importance to support DT with a RLL approach.

To support inclusive DT in rural areas, multi-disciplinary approaches and various methods are needed (for example, brainstorming sessions, future workshops, gamification, heuristic evaluation, personas), along with tools that can support these processes (Scholl & Kemp, 2016). Actor engagement in a LL context is an iterative process characterized by complex interplay between different phases and activities, including planning for engagement, realizing planned activities in real-life settings, and reflecting upon the plans and actions as a way to sustain user engagement and commitment to use the innovation in their everyday use (Habibipour, 2020). In the DigiBy project, the engagement of multiple actors was supported with a structured approach to each individual local pilot. This made it possible to keep track of timelines, innovations, actors, and research questions to be emphasised, as well as supporting a streamlined approach to the local pilots, which in turn facilitated knowledge sharing and producing research results.

Digitalization, digital innovation and digital infrastructure

In RLLs, digitalization has a broader scope than merely digitizing a business. Digitalization as a key component integrates both digital innovations that will be co-created by various stakeholders and rural residents, as well as the digital infrastructure (Verhoef et al., 2021). In RLLs, digital infrastructures are intertwined with the innovations that are usually in the fuzzy front-end stage. “Digital infrastructure” here refers to hardware, software, data (open or closed data), networks (for example, 4G, 5G, fiber, Wi-Fi), as well as other IoT-solutions such as smart cameras, sensors in smart agriculture, and wearables. In relation to this key component, a shared understanding of the purpose of the digital innovation and the expected value the innovation can offer is vital.

Identifying specifically what a digital solution offers, including its broader ecosystem and value chain, with hardware, software, services, data, and communication

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

network is important to facilitate ownership, agreements, licences, and so forth. The aim of the local pilots in rural contexts was to facilitate long-term DT by experimenting with digital innovation. To illustrate, in the DigiBy project we aimed at buying all equipment, having low cost licences that could be transferred to local pilot owners after the DigiBy project ended. In the RLLs, our study also identified that digital innovations not only transform organisational processes, but also societal and individual processes. One example was the digital lock at a local grocery store, which impacted peoples' buying and travelling habits. Hence, we can see that digital innovations transform behaviours as well as processes. Thus, it is important to have an open mind when designing and evaluating DT pilots.

Quintuple Helix

All LL activities involve quadruple helix networks, that is, both public and private sectors, academic institutions, and citizens. However, due to rapid climate changes occurring in natural environments and ecosystems, an urgency is in place to follow general recommendations from the latest IPCC report to consider climate change in innovation projects depending on the context (Masson-Delmotte et al., 2021), which emphasizes the importance of including all environmental aspects.

The quadruple helix of innovation should therefore include “natural” environments, as the fifth key actor in the DT process for rural areas. This is called the “quintuple helix” of innovation (Carayannis et al., 2012), which adds the helix (perspective) of natural environments in various societies. Hence, it is important to consider those affected that do not have a voice, which could be the environment, but also people, for example, unborn children. This quintuple helix approach can also facilitate collaboration in RLLs and their DT processes, that is, risks and workload can be divided among various partners. However, the helix has no formal partnership or dedicated leadership, as is also the case in ULLs. Therefore, identifying relevant stakeholders is one of the most challenging tasks (Zavratnik et al., 2019), which should be carried out while planning DT processes. Aspects such as stakeholder motivation to contribute, their objectives and intentions, as well as their expected level of engagement, should be stated up front. Furthermore, the quintuple helix component should help RLL

organizers to define the different roles of engaged partners including individual users (rural residents), and their degrees of engagement. The partners might have passive roles such as “affectees” (Ståhlbröst & Holst, 2017), who are affected by, but do not influence the DT process, along with more active roles, such as tester, experimenter, innovator, or lead participant.

In the DigiBy project, the quintuple helix approach took the form of collaborations between researchers, municipalities, local grocery stores, rural residents engaged in village associations, end-users of the suggested solutions, and also specific aspects of the environment, as seen for example with the digital lock solution. In this project, the involved actors took different roles, for example, where researchers had a facilitating role in investing, implementing, and evaluating the digital innovations. The municipalities also had a facilitating role focussed on knowledge sharing and knowledge transfer between different local actors. They also had vital network connections, important for the DT process. The local actors (for example, local store owners, citizens, end-users) had a diversity of roles, spanning from “need owners” to affectees. In RLL pilots, the environment become a ubiquitous actor that is an integral part of the rural residents' activities. To conclude, when engaging in quintuple helix processes it is important to consider and clarify the roles and expectations of the different actors.

Discussion and Conclusion

In contrast to ULLs (Chronéer et al., 2019), RLLs do not merely consider LLs as a milieu or a place-specific context. Instead, the RLLs are an approach that facilitates processes of local DT pilots in rural areas, where identified key components are an integral part of the overall processes of experimenting and evaluating digital innovations in real-world contexts. In our study, some specificities that have been identified regarding RLLs should be taken into consideration when designing DT pilots. Firstly, RLL pilots are contextually situated, since they are driven by local needs as they are experienced and expressed by local actors, for example, a local grocery store needing to broaden their business to become viable. Secondly, the rural DT pilots in northern Sweden are experimenting with innovations at a high technology readiness level (TRL, for example, using digital locks, digital touch screens, digital package boxes) to create initial instant value for its actors, which

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

is of utmost importance in rural areas due to the vulnerability of local businesses that might have a somewhat limited customer basis. Related to that is the fact that the pilots are being carried out in real-world contexts with real customers and other actors. This requires fast, established, and dynamic processes, but also an investment of time from local actors in the pilot.

In our study the RLL pilots were geographically distributed with several small pilots in a diversity of villages, in contrast with ULLs that usually have one (somewhat) controlled place for the LL activities. For instance, in urban contexts, cities are considered as ULLs, which is associated with long-term and sustainable planning (Evans & Karvonen, 2011; Steen & Bueren, 2017), while RLLs have shown to be more distributed in character. In addition, RLL activities can be considered as small-scale activities that are carried out within defined boundaries of a local pilot, while involving a possibly limited number of actors and rural residents. As a result, having a deep understanding of qualitative aspects should be sought. Rural pilots that are carried out in distributed real-world contexts with real customers in live situations, require that the pilots are facilitated and supported with frameworks that enable knowledge transfer and building both among local actors, as well as the other actors in the quintuple helix collaboration.

Based on the findings of this study, we propose the following definition of RLLs:

A rural living lab is a local innovation pilot that aims to solve rural challenges and contribute to inclusive digital transformation of society by engaging quintuple helix actors including rural residents and natural environments in real-life digitalization experiments.

Important to note here is that the proposed definition addresses those RLLs that pursue pilots aimed at DT. Therefore, this definition cannot be generalized to all other types of RLLs, for example those focused on non-digitally enforced social goals, such as strengthening inclusiveness in the society, advancing eco-cultural restoration, increasing land-based learning, or fostering entrepreneurship in tribal contexts.

Overall, our results revealed that the proposed RLL

framework highlights some key differences between ULLs and RLLs. The first and most important aspects relate to the character and philosophy of the way RLLs and ULLs can be formed and interpreted. Even though ULLs are mainly considered as a context in which to develop innovations, RLLs can instead be seen as an approach that aims at solving issues that emerge locally while, facilitating DT in rural areas. In addition to that, the scope of activities in RLLs is more focused on short-term activities compared with Urban LLs, the latter which have more long-term planning for defined activities. Furthermore, in contrast to ULLs that usually involve a quadruple helix of innovation, RLLs also necessarily include the natural environment as a fifth actor that influences DT processes in rural areas.

RLLs facilitate piloting digital innovation in rural areas with an aim to include and empower a multitude of rural stakeholders in various DT activities. In this study, we identified five key components that supports the design of DT pilots in rural areas. RLLs can be expected to represent a local ecosystem where multiple involved actors are motivated by various objectives, yet at the same time benefit from their engagement, for example, a collectively owned local grocery store. A RLL should also facilitate engagement by providing tools for planning and evaluating local pilots in real-world contexts. The RLL approach can thus be seen as an innovation management tool for inclusive DT of rural areas.

The RLL framework is suited not only for designing local DT pilots, but can also support the structure of work in a policy process, according to officials working with policy processes for local development. Here the framework can be used in various stages of the policy process to collect input from target groups, spanning from politicians' visions to individual needs.

Based on the results of this study, potential avenues for future research are revealed. One limitation of this study was to restrict RLLs to those aiming to enable DT processes. However, a clear classification and categorization of RLLs seems of vital importance toward fostering an enhanced understanding of what differentiates between RLLs and ULLs, and why. Another interesting topic for future research is to study how a RLL can be seen as a “model” that describes a set of propositions or statements expressing relationships among constructs (here key components). For example, how different ways of governing and control might be

Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

affected by a rural context, or how actors (quintuple helix) and their engagement approach might differ, depending on the digital innovation type as well as the digital infrastructure in rural areas. Our hope is that the presented RLL framework and definition can be used as a starting point for facilitating and supporting DT processes in rural areas, by further iteration of design cycles and evaluations in real-life settings.

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Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

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Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

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Rural Living Labs: Inclusive Digital Transformation in the Countryside

Abdolrasoul Habibipour, Johanna Lindberg, Mari Runardotter, Yomn Elmistikawy, Anna Ståhlbröst, & Diana Chronéer

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Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

“ He who does not trust enough, will not be trusted.”

Lao Tzu

Ancient Chinese philosopher and writer

Urban Living Labs (ULLs) have become a popular instrument for finding solutions to urban challenges faced by cities. While ULLs have achieved a certain level of normalisation in cities, a general lack of understanding remains regarding the character and purpose of the ULL phenomenon, which leaves many challenges open to be overcome. One challenge involves the potential impact of ULLs in contributing to meaningful transformative changes. By combining a literature review with a comparative case study of three ULLs in the city of Groningen, the Netherlands, this study confirms and adds to current theoretical positions taken about how to overcome the challenge in terms of holding a shared ideology and reviewing the concepts of agency and power. It also shows that opportunity comes along with trust-building among stakeholders in ULLs, as a way to enhance their potential in practice. Consequently, this study calls for further research regarding underexplored theories and models of ULLs, power dynamics in ULLs, and into their self-sustaining character, both in terms of social adoption and ownership, as well as financial sustainability.

1 Introduction

Urban living labs (ULLs) have arisen in cities as a response to a pressing challenge (Marvin et al., 2018): *How can cities provide economic prosperity and social cohesion while achieving environmental sustainability?* In this perspective, the core idea of ULLs is that urban sites can provide a learning arena within which the co-creation of innovation can be pursued between research organisations, public institutions, private sectors, and community actors (Liedtke et al., 2012).

Not only in practice, but also in academic spheres, the concept of ULLs has increasingly gained interest in recent years (Schuurman, 2015; Hossain et al., 2019).

Yet, despite the growth of ULLs and their experimentation, their nature and purpose as an empirical phenomenon is still not fully understood (Bulkeley et al., 2016). This is partly because the acceleration and normalisation of ULLs in practice has proceeded much more rapidly than the development of evidence and theoretical understanding about them

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

(Bulkeley et al., 2016; Marvin et al., 2018). As such, international comparison and systematic learning is lacking on how ULL impacts can be scaled up to achieve transformative changes (Marvin et al., 2018), and how they can effectively facilitate urban sustainability transitions (Evans & Karvonen, 2013; Nevens et al., 2013). Such transitions are about changes in markets, policy, culture, technologies, and infrastructure, as well as in human behaviours and practises (Bulkeley et al., 2010; Frantzeskaki & Loorbach, 2010; Schaffers & Turkama, 2012; Voytenko et al., 2016).

A key point therein is to examine the role of (urban) experiments to govern these transitions, and in doing urban innovation and governance (Marvin et al., 2018) to gradually transform stable regimes (Kemp et al., 1998; Schot & Geels, 2008). Existing regimes or systems seem to be difficult to pry off because they are stabilised by processes that create path dependencies (Grin et al., 2010; Loorbach & Rotmans, 2010; Neef et al., 2017). ULLs are one way to affect change (Schaffers & Turkama, 2012; Marvin et al., 2018), because they are similar in approach to “transition management” (Loorbach & Rotmans, 2010), and centre on the use of experiments, including less directed processes in which innovation and ideas are demonstrated, tested, and experienced for gain (Kemp et al., 1998; Bulkeley & Castán Broto, 2012). The degree to which these experiments lead to regime transitions seem to depend on growing social networks, innovations, and learnings that they establish (Brown & Vergragt, 2008). Existing research, however, mainly focusses on the aims and workings of ULLs instead of critically reviewing their implications (Bulkeley et al., 2016), their essence (Hossain et al., 2019), or to what extent they shape new governance modes (Marvin et al., 2018). Some challenges in ULLs, therefore, link with temporality and unpredictable outcomes (Hossain et al., 2019), such as financial sustainability (Gualandi & Romme, 2019), scalability, diffusion, and impact (Puerari et al., 2018; von Wirth et al., 2018), and the redistribution of agency and risks (Loorbach & Rotmans, 2010; Smith & Raven, 2012; Burch et al., 2018).

This study addresses this research gap by focussing on how the relationship between funding, stakeholder roles, and process outcomes in ULLs can contribute to transformative changes. The main research question

is: *How does the trinity of funding options, stakeholder roles, and outcomes in ULLs influence their impact creation for transformative changes in cities?* Tensions between these aspects were observed by Hodson and colleagues (2018) in the UK, which are still present in today’s ULL practises (Scholl & de Kraker, 2021).

The paper is structured as follows. First, it elaborates on current literature about ULLs and the trinity under study to explore and identify current approaches and theories. Second, it explains and justifies the methodology chosen in the literature review and comparative case study in the context of the city of Groningen. Then, it provides the results of the empirical study focussed on funding options, stakeholder roles, outcomes created, and impact. Lastly, the paper presents the importance of trust building in ULLs to overcome the particular challenge under study, highlighting its theoretical and practical implications, as well as limitations and recommendations for further research.

2 Literature Review

2.1 Origin and positioning of urban living labs

Although the origin of the living lab movement can be traced back to the 1960s, and later, the founding of the European Network of Living Labs in 2006 (Hossain et al., 2019), the emergence of ULLs more generally started following the 2008 Global Economic Crisis. Since then, cities have struggled to find solutions to challenges faced via three sets of issues: 1) there is no singular pathway towards urban sustainability (De Jong et al., 2015), 2) interest increased in the potential of experimentation in place-based contexts to overcome rigidity in existing socio-technical systems based on private contexts (Chesbrough, 2006; Almirall & Wareham, 2011), and 3) various stakeholders, like research and technology institutions, started to see urban environments as places to support local communities, as well as grassroots initiatives that align with national innovation (Paroutis et al., 2014; Luque-Ayala & Marvin, 2015; Marvin et al., 2018). In fact, ULLs and various other parts of cities can be positioned as a form of experimentation towards a broader shift in the character of urban governance (Bulkeley et al., 2016; Evans et al., 2017; Steen & van Bueren, 2017), and as such seems to be able to enhance learning about place-based contexts to achieve changes in socio-technical and socio-ecological systems by continuously enrolling new sites and actors (Liedtke

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

et al., 2012; Baccarne et al., 2014; Bulkeley et al., 2016; Voytenko et al., 2016; Scholl & Kemp, 2016; Astbury & Bulkeley, 2018; Marvin et al., 2018; Steenbergen & Frantzeskaki, 2018).

2.2 Defining urban living labs

Defining ULLs has been an ongoing challenge, both in scientific studies and in practise. While Voytenko and co-authors (2016) argued that there is no universal ULL definition, Chron  er and colleagues (2019) in contrast developed a “unified” definition of living labs (LLs). In general, however, these two streams are identifiable by their opposition. On the one hand, LL definitions stem from open innovation theory and co-creation (see for example, Westerlund & Leminen, 2011; Leminen, 2013). On the other hand, ULL definitions stem from management transition and urban governance, thereby viewing the concept as a governance model in which experimentation and learning can be centred (See for example, Bulkeley & Cast  n Broto, 2012).

In this study, we use the following definition: “*Urban living labs constitute a form of experimental governance whereby urban stakeholders develop and test new technologies, products, services and ways of living to produce innovative solutions to the challenges of climate change, resilience and urban sustainability*” (Bulkeley & Cast  n Broto, 2012; interpreted by Voytenko et al., 2016), because it shows two aspects. First, ULLs constitute a form of experimental governance with and among urban stakeholders. Second, it underpins the shared focus on finding solutions to today’s urban challenges and reaching urban sustainability. Both are relevant, because urban and societal challenges nowadays need collaborative efforts across sectors as well as between disciplines (Evans et al., 2015; Bulkeley et al., 2016; Voytenko et al., 2016; Marvin et al., 2018; Menny et al., 2018; Hossain et al., 2019).

2.3 Urban living lab typologies

Discussion remains open regarding ULL typologies,

Table 1. Strategic, Civic and Organic ULL characteristics (Marvin et al., 2018)

<i>Characteristics</i>	<i>Strategic</i>	<i>Civic</i>	<i>Organic</i>
Lead actors	Innovation agencies, national government, and corporate business	Municipal and local authorities, higher education and research institutes, local companies, and SME’s	Civil society, communities, NGOs, and residents.
Urban imaginary	Urban as a testbed that can be replicated or generalised	Urban as a contingent and historically produced context	Urban understood in particular ways by local communities
Primary purpose	National innovation and technological priorities	Urban economic and employment priorities	Community social, economic, and environmental
Organisation form	Competitive (Urban selected site as a site for experimentation)	Developmental (Partnerships formed by local actors)	Micro / Single (Multiple forms of community organisation)
Funding type	One-off or competitive	Co-funding or partnership	Improvised, ranging from subsidies to investing voluntary time or (personal) resources
Analogue	National innovation	Urban technology policy	Grassroots innovation

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

since the cases investigated so far have differed, and the criteria that form the basis for the typologies are still not widely agreed upon. Neef and colleagues (2017), for example, differ between “Product Oriented Labs” and “Urban Transition Labs” based on the theoretical foundations of open and user innovation. Leminen and colleagues (2012), as well as Bondarenko and co-authors (2019) proposed five types of ULLs based on the stakeholder who drives the activities: Enabler, Provider, Utilizer, User, and Researcher-driven. Additionally, and as used in this current study, Marvin and colleagues (2018) empirically compared 50 ULLs across Europe, differentiating between three types of ULLs based on their geographical scale and urban dimension, see Table 1.

Strategic ULLs contain larger scale technological development programmes procured by state intermediaries and involving private partners. They are often state sponsored, including private investments to build local capacity and enhance international competitive position. **Civic ULLs** involve municipal governments and local stakeholders. Their goals tend to have a strong local character and focus on urban priorities. Hence, co-funding in these LLs is widely used, in combination with private investments and national or European subsidies. **Organic ULLs** focus on specific local and contextual issues, like social needs or urban poverty, on the community- and neighbourhood level, and link these with grassroots activities literature in socio-technical innovation (Seyfang & Smith, 2007). The key actors are civil society and non-profit organisations that try to mobilise residents around various projects.

2.4 Stakeholder roles

ULLs are, indeed, associated with open innovation and user innovation (Hossain et al., 2019), which are extremes of the user involvement spectrum (Leminen, 2013). Open innovation functions on the idea that businesses cannot operate on their own, and instead look for external resources to improve their developments (Chesbrough, 2006). User innovation highlights the necessity of both passive and active roles by citizens in innovation processes (see for example, Bergvall-Kåreborn & Ståhlbröst, 2009). Both roles are needed to identify needs and ideas, as well as to validate and formalise learning outcomes (Menny et al., 2018).

As such, scientists have tried to come up with stakeholder roles. Often referred to and used for typologies are the *Enabler*, *Provider*, *Utilizer*, *User*, and *Researcher* roles (Westerlund & Leminen, 2011; Leminen et al., 2012; Schuurman et al., 2016; Bondarenko et al. 2019). Enablers are organisations that make things happen and that support ULL activities in resource terms. Providers are development organisations that provide something to ULLs like knowledge or expertise. Public or private organisations that use ULLs as a strategic business development tool are Utilizers. Users reflect the end-users of products or citizens involved in an urban context. Researchers are both providers of knowledge, as well as generators of new scientific knowledge in diverse fields, like urban policy.

2.5 Funding options and outcomes created

Recently, The Funding Mix Framework (FMF, Figure 1) is set up by Gualandi and Romme (2019), who provide a first holistic view of the relationship between stakeholders, value creation, and funding options. It consists of four funding methods: *Pay per service (PPS)*, *Subsidies (SUB)*, *Out of Network Funds (ONF)*, and *Cross Financing (CRF)*. PPS revenue arises from services in ULLs, mostly paid by private partners that seek economic value. SUB are often given by public partners to serve the strategic level of ULLs. ONF are equal to SUB, however, provided by partners not involved in the ULL constellation, like EU funding. CRF involves new ways of funding, such as renting out the physical space of ULLs.

Additionally, the authors argue that value created can be *economic*, *business*, and *public*. The first is about tangible and measurable outcomes, like new start-ups generated (Baccarne et al., 2014). The second is an extension of economic value, such as training provided. The third is about non-financial impacts of ULLs that, following Baccarne and co-authors (2014), relate to realizing policy goals. In these terms, “public value” is considered the most important in ULLs (Guzman et al., 2013), as they have a strong focus on social value creation and civic engagement (Baccarne et al., 2014). The social acceptance of innovation and consumer practises therefore seems to be a crucial accelerator of sustainability transitions (Schaffer & Turkama, 2012; Markard et al., 2020; Stoeglehner, 2020), while it is as difficult to measure as urban safety, environmental awareness (Ståhlbröst, 2012), or the early adoption of

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

new practises (von Wirth et al., 2018).

Moreover, long-term funding is needed for long-term operation, knowledge accumulation, scalability, and impact creation (Guzman et al., 2013; Veeckman et al., 2013; Evans et al., 2015). Indeed, ULL outcomes and studies have focussed on incremental rather than radical outcomes (Hossain et al., 2019), since successful ULLs are inherently local, (Burch et al., 2018), and from there viewed as the starting point for scalability and transformation at different scales (Astbury & Bulkeley, 2018). Despite this, Mai (2018) showed that it is small scale ULLs that struggle hardest to achieve appropriate funding. Thus, business models have remained underdeveloped and unsustainable because they depend on public funding that requires strict justification, via project-based injections, or funding from universities and regional development agencies (Schaffer & Turkama, 2012).

2.6 Impact creation and transformative changes

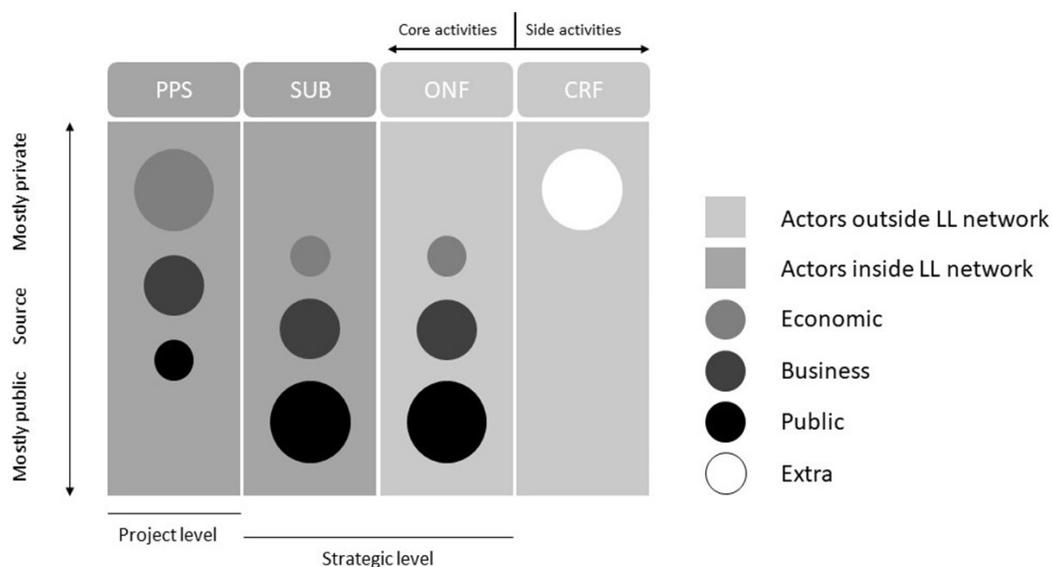
Von Wirth and colleagues (2018) showed three ideal-typical ways of creating transformative changes in ULLs: *Embedding*, *Translating*, and *Scaling*. The first is about the adoption and integration of an approach or outcome in existing local structures. The second is

about elements of experiments or lessons learned being replicated and reproduced elsewhere. The third is about experiments becoming “bigger in terms of content and remit” (Ibid). Herein, "transformative changes" are viewed as the de-institutionalisation of existing socio-technical structures, along with new more sustainable ones being created, diffused, mainstreamed, and institutionalised again (von Wirth et al., 2018).

2.7 Current debate on solving the particular challenge

The current debate on solving the issue between funding, stakeholder roles, and outcomes, provides two positions. First, researchers are calling for a shared ideology within ULLs to help operations in such a way that complementarity stands above competition between stakeholders (see for example, Mangan & colleagues, 2009; or Gualandi & Romme, 2019). Second, debate continues about the various types of agency and power of stakeholders involved. For example, Burch and co-authors (2018) explained that ULLs redistribute agency and power to non-traditional urban stakeholders, while Menny and colleagues (2018) introduced a cyclical process of redistributed power throughout different ULL phases. Also, Savini and Bertolini (2019) demonstrated that ULLs relate to the political dynamics of institutional stability and change.

Figure 1. The Funding Mix Framework. Source: Gualandi & Romme (2019).



Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

Thus, it seems that opportunity lies in a change of mindset towards shared ideologies, which requires reviewing the concepts and meaning of agency and power.

3 Methodological Notes

3.1 Research design

This study uses a qualitative research design and combines a retrospective literature review with a comparative case study analysis. Indeed, case studies are arguably the most used methodology in ULL research (Greve et al., 2020). Yet, the method of case study here seems useful to gain a holistic overview of the context under investigation (Punch, 2013), and is particularly appropriate for collecting data to study a novel phenomenon in an explorative manner (Yin, 2002). This reflects the situation in ULL literature, since it is recent, quickly expanding, and contains competing definitions (Greve et al., 2020).

3.2 Research approach: literature review and comparative case study

First, a retrospective literature review was made to understand the historical development of ULLs, starting with two key documents. First, the *Urban Living Labs: Experimenting with City Futures* scientific reader from Marvin and colleagues (2018), and second, an academic paper “A Systematic Review of Living Lab Literature” by Hossain and co-authors (2019). Both documents pay particular attention to LLs in urban contexts and as means for sustainable development. Subsequently, the “snowball” method and “pearl-growing” method were both applied to find additional relevant literature regarding the topic under study, by focussing on recognized authors and often mentioned key terms. Herein, no resource type scope was applied, such as restricting to academic articles only. As such, the authors ended up with a wide range of resource types. In this way, the snowball method allowed for a relatively fast and holistic exploration of the recent history of ULL literature, including the identification of often mentioned terms. The key terms (Urban Living Labs, Impact, Diffusion, Outcomes, Value, Stakeholder Roles, Funding Model, Financing) were then put into Google Scholar in the pearl-growing method for additional literature.

Second, a comparative case study (Punch, 2013) was

conducted using semi-structured interviews to collect detailed data of cases by understanding and accessing stakeholder perspectives of the situation, and also to mutually explore the research question. Three cases were selected first that met four specific ULL criteria, and second which were labelled as an “organic”, “civic”, or “strategic” ULL. The criteria were established for assessment while reading in online policy documents, on their website, and about the mission, vision, and goals of the ULL. As far as general ULL criteria were concerned, the cases: 1) were geographically embedded in a particular location, 2) had to consist of urban stakeholders in the co-creation triple- or quadruple helix model, 3) focused on urban sustainability, and 4) used experiments or test moments to generate knowledge or learn about urban sustainability.

Additionally, the specific criteria to label the cases as an organic, civic, or strategic ULL are as follows. The strategic ULL, 1) operates on a city, regional, or national scale, 2) has involvement or a link to innovation agencies or agreements, 3) is financed by a lump sum in the relatively short-term (although not necessarily), 4) falls into a wider sustainability strategy, and 5) is competitive in nature. The civic ULL, 1) operates within a city scale, 2) is focussed on local urban priorities, and 3) consists of a clear partnership between urban stakeholders that initiated the ULL. The organic ULL, 1) is active on a community- or neighbourhood level, 2) is not initiated by governmental parties, 3) focusses on specific local contextual issues that link with social needs or ideological values of the initiators, and 4) is a strategic niche (Seyfang & Smith, 2007).

3.3 City context and case study descriptions

The case studies for our research were located in the city of Groningen. It is the largest and youngest city in the Netherlands’ north. The surrounding rural areas are entitled *krimpregio’s* by the National government, meaning they face a declining population and related urban challenges. Moreover, Groningen is a typical student city with one in four being a student. The economy of the city has mainly been focussed in recent years on services and energy, such as the natural gas company GasUnie. Focus is currently shifting to tourism, ICT, energy, and the environment, like the Hydrogen Valley HEAVENN EU-project. The cases are described below.

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

Organic ULL: Stichting Paddepoel Energiek (SPE)

SPE is a citizen initiative to improve energy neutrality in the neighbourhood Paddepoel, originally built in the 1960s to show opportunities in typical old Dutch neighbourhoods and buildings. It achieved some success, since Paddepoel became a partner in the EU-project “Making City”, although it is often associated as a not-to-be-in neighbourhood. Their main aim was to turn Paddepoel into an energy neutral neighbourhood in 2035, both technically and socially. Also, everyone living in Paddepoel could join the initiative and learn from their energy coaches about energy production and consumption. Additionally, the neighbourhood collaborated with the municipality of Groningen, educational institutions, and local businesses that develop, for example, solar panels. The period we studied was roughly during its “stichting” [1] period, from February 2016 until October 2019.

Civic ULL: Urban Gro Lab (UGL)

The UGL is a partnership of the municipal department of urban development and the Faculty of Spatial Sciences at the University of Groningen. Together they envisioned the city as itself a ULL in which research could be conducted that focuses on local socio-spatial challenges by bridging science and practise. Thus, it tried to function as a source of knowledge and inspiration by collaborating with urban stakeholders and involving citizens. As such, the UGL was run by a yearly changing lab coordinator. The UGL existed for almost five years and was purposefully intended to be and function as an ULL for spatial research and innovation. The period under study was from November 2015 until it stopped in November 2018.

Strategic ULL: Welcoming International Talent (WIT)

A “Gentlemen’s Agreement” called “Het Akkoord van Groningen” between the province of Groningen, the municipality of Groningen, the knowledge institutes in the city, and the University Medical Centre Groningen has existed since 2005. It is a cross-party collaborative platform for joint coordination and decision-making that agreed upon envisioning a sustainable future for the city of Groningen as a knowledge city by focussing on various themes. The focus in this study was laid on “internationalization”. The ULL aimed to make Groningen “stickier” by attracting, retaining, and integrating international residents and students better in the city, while maintaining a high level of social

cohesion and liveability to enhance the innovate capacity. The WIT finds it basis within wider sustainability strategies at the EU, regional, and city levels. For example, the EU Cohesion Policy and the Next City Policy document. Also, Groningen is a “European Good Practise” city in the URBACT WIT Transfer Network. The period under study was from November 2016 (the review moment “Gentlemen’s Agreement” together with local policies) until November 2019. The ULL is still active and functioning.

3.4 Data collection and analysis

In total, six interviews and one mail questionnaire were conducted with eight interviewees in October and November 2019. The interviews lasted between 38 and 90 minutes and were taken at the work location of the interviewees, except for one in Groningen city centre. The mail questionnaire contained the same questions as the interviews and was applied based on the preference of respondents. In this study, the questionnaire is therefore viewed as a kind of “interview held by mail”, and as such included in the data analysis. The interviewees were governmental employees (2), governmental trainees who coordinated activities (2), civil initiators (2), a university employee (1), and a private sector person (1). The interviewees were chosen as they had leading positions in the Groningen ULL activities and projects. The semi-structured interviews were transcribed manually and analysed using the coding and memoing methodology (Punch, 2013). Analysis began by scoring out irrelevant information. Then, codes were attached to specific pieces of texts, resulting in 42 to 82 codes per interview. Next, all codes were clustered to find cross-connections between codes, clusters, and interviews. Alongside of this, the memoing technique (Punch, 2013) was used to put memos on different spots in the transcripts to move from the empirical to the conceptual level while analysing the data collected.

3.5 Ethical considerations

Prior to the interviews, interviewees received an interview guide and interview permission statement. The interview guide concerns an introduction to the research, its objectives, and questions asked. With the interview permission statement, respondents were asked to agree to recording the interview, and to the use of information and data collected. Transcriptions were provided to the respondents for approval, or any

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

changes needed regarding their anonymity or answers given.

4 Comparative Case Study Results

4.1 Stakeholder roles in urban living labs

In all cases a core group was identified that was responsible for the funding and operation of the ULL (see blue contours in Figure 2). In the SPE and WIT, the core group existed out of the Enabler and Utilizer roles, whereas in the UGL the core group encompassed the Enabler, Provider and Researcher roles because of the partnership between the municipality and university. Municipalities were in all cases involved in the core group as Enablers, which was in line with observations from Scholl and Kemp (2016). In SPE and WIT, the Utilizers were involved because of the funding possibilities and expertise provision, which was already inherent in the UGL partnership. The Researcher role in SPE was absent since it did not intend to generate new knowledge per se, while the UGL and WIT did.

4.2 Funding in urban living labs

The SPE is mostly financed by PPS and SUB methods via private businesses and the municipality. The UGL is also financed by PPS and SUB methods. The WIT is financed by all methods available and focuses on various outcomes. While it is acknowledged that the FMF is not a static model, notably PPS in the UGL, and PPS and SUB in WIT contrast to the FMF, since the PPS streams focussed on public outcomes, and the SUB obligated private outcomes. CRF was found to be complementary to other main funding streams aligning with the FMF. For example, payments by the housing association in SPE that informed and advised tenants as side-activity. Moreover, WIT seems most eligible to receive ONF due to legitimation reasons as the geographical location they serve is bigger compared to organic or civic ULLs.

Additionally, the interviewees mentioned university funding, political will, and the role of civil servants as important in funding provision. The Dutch educational system of universities has limited funding for “experiments” given that their core task is doing scientific research. Thus, political will is important for budgeting ULL projects in the coming years to ensure continuation. Meanwhile, the role of civil servants was

criticized by the interviewees. In general, it was thought that they handle too strict justification criteria for subsidies provided, thereby limiting the freedom of the ULL to “experiment”, especially in the cases of SUB and ONF. These observations are in line with the SWOT analysis of LLs made by Guzman and colleagues (2013), and the accountability discussion raised by Astbury and Bulkeley (2018).

4.3 Outcomes in urban living labs

Increased social networks and mutual learning were found in all cases and indicated as important by interviewees, whether or not focussed on in advance. These are clearly felt outcomes, though not directly measurable. In fact, Brown and Vergragt (2008) argued that both are of immense importance if ULLs want to contribute to transformative changes. Indeed, most value strived for in ULLs is of public value (see black circles in Figure 3) to aim for societal and urban improvements. In addition, from our research we found that when economic value was pursued it was done by private parties or for specific short-term services. The interviewees argued that while some ULL experiments were seen as failures, they still brought outcomes that one might benefit from in the future, or that potentially could initiate wider transitions in provision systems, regardless of the type of ULL involved.

4.4 Impact creation in urban living labs

Impact creation seems to depend on the interests of outsiders (at translating) and the geographical scale the ULL is already active at (scaling), together with the available possibilities to embed lessons in local structures or organisations (at embedding). The SPE scaled and translated outcomes, without initiating them. Rather, interest came in from outsiders, and the further obligation to become a stichting made them do it. The UGL embedded outcomes in local structures within its geographical focus. However, their impact remained sporadic due to a lack of long-term vision, which ranged from products created, experiences gained, networks built, or education improved. The WIT embedded and translated lessons learned via either the integration of outcomes in local structures, like policy plans, or via the URBACT Network to other city contexts. Scaling was not observed as the WIT already focused on (inter-)regional scale and “everyone” in the Akkoord van Groningen.

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

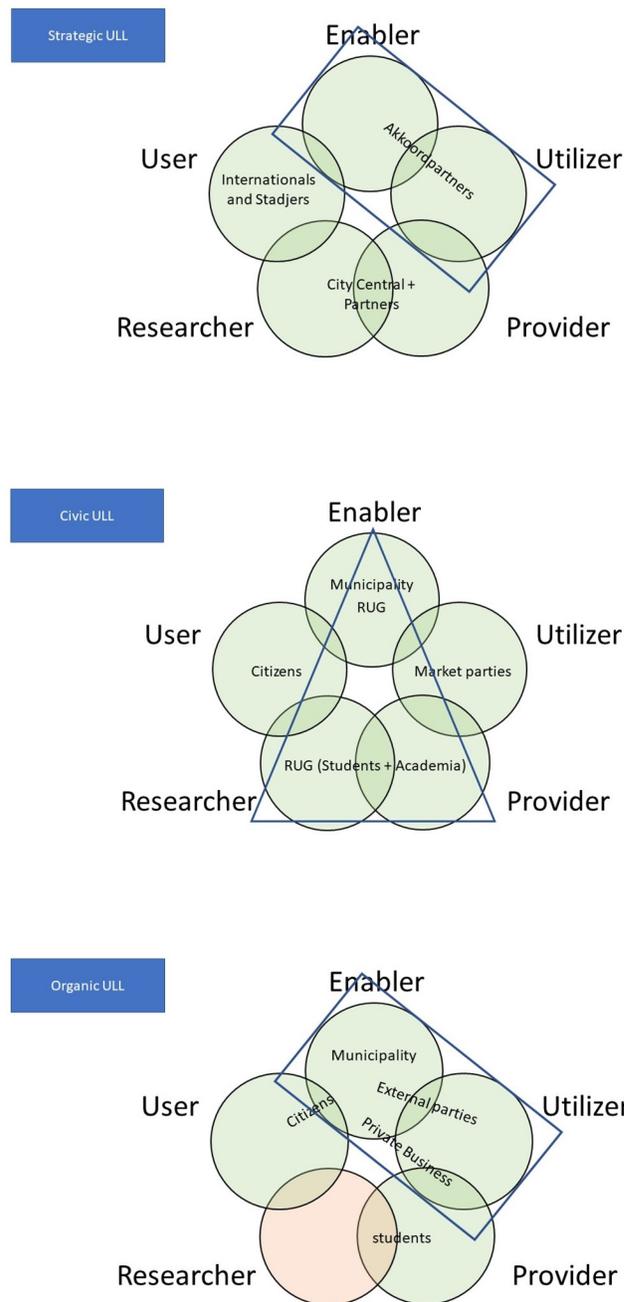


Figure 2. Stakeholder roles in the organic, civic, and strategic ULLs. The blue contour implies the core group of stakeholders most responsible for funding and operation activities. The positioning of each stakeholder is based on comparing the theoretical description with practical operation. The figures highlight the importance of the Enabler role in ULLs, as well as the potentially unconditional Researcher role in organic ULLs. Source: Authors.

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

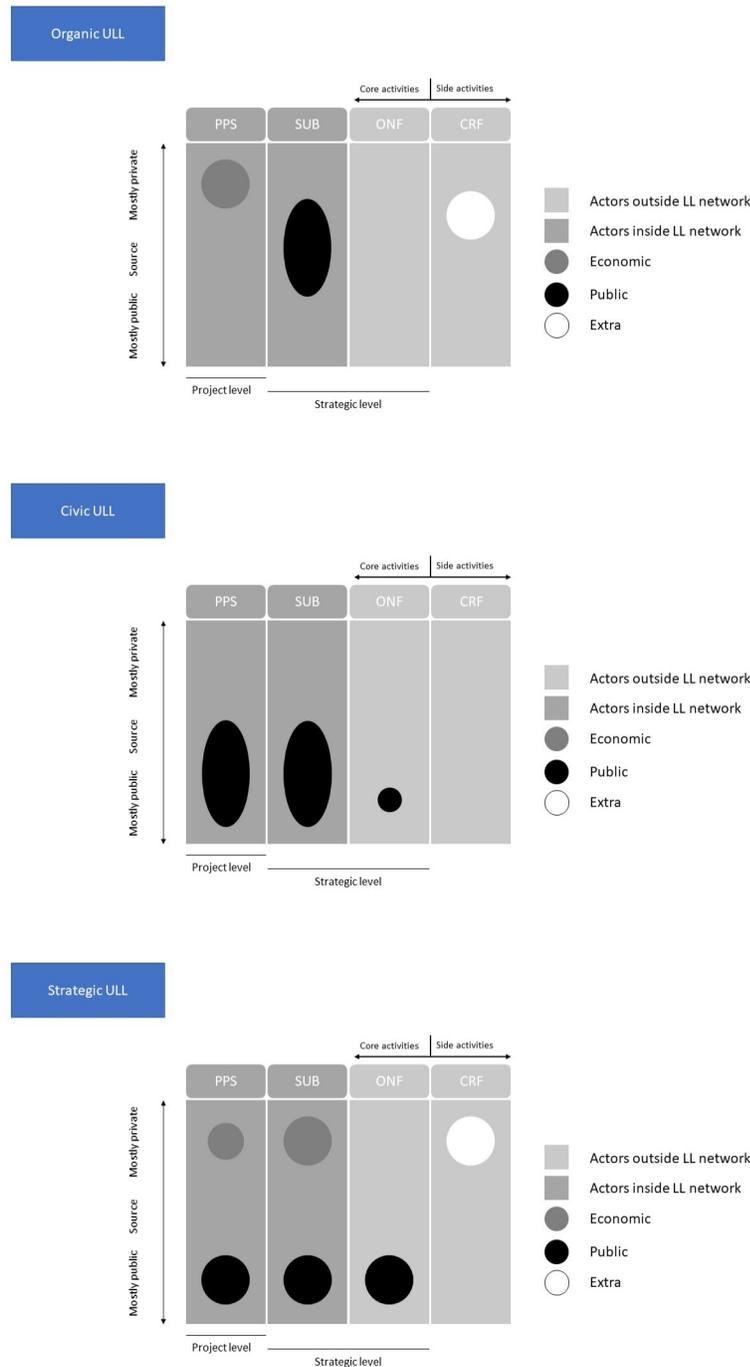


Figure 3. Theoretical funding model in the organic, civic, and strategic ULLs. Most important observations are, 1) the eligibility of ONF in the strategic ULL, 2) the general focus on public outcomes in civic and strategic ULLs compared to organic ULLs, and 3) the sporadic and ambiguous use of CRF. Source: Authors based on Gualandi and Romme (2019).

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

5 Conclusion

5.1 Theoretical implications: urban living labs and transformative changes

In this study, the research question was presented: *How does the trinity of funding options, stakeholder roles, and outcomes in ULLs influence their impact creation for transformative changes in cities?* Since the 2008 Global Economic crisis, ULLs have emerged in the urban context to learn collectively about urban development as a long-term process. While ULL practitioners and scientists have been aware of the potentials inherent in ULLs for several years (Bergvall-Kåreborn & Ståhlbröst, 2009; Almirall & Wareham, 2011; Westerlund & Leminen, 2011), the continuous searches to limit individual political and financial risks among urban stakeholders have hindered the potential of ULLs. This study therefore emphasized that it is not individual aspects in the trinity highlighted that improve impact creation in ULLs, rather trust building among stakeholders in ULLs and their place-based contexts seems necessary to contribute to transformative changes in the long-run. That way, ULLs can strengthen their foreseen role as a form of experimentation in a broader shift involving urban governance, and as such can achieve gradual changes in socio-technical and socio-ecological systems based on a continuous learning process among actors and urban sites.

5.2 Theoretical implications: concepts and methods

The theoretical contribution of this study is mainly twofold. First, it follows up on Greve and colleagues (2020) who pointed to the opportunity for scholars to apply unused theoretical approaches in ULL literature. Hence, this study has shown the importance of, for example, the exploration in practise of the FMF and ULL typology of Marvin and colleagues (2018) to enhance the theoretical understanding of ULLs in certain domains. We thus call for researchers to explore existing theoretical approaches more extensively, instead of continually seeking to provide new approaches, categories, or models. A good example of this is the recent study by Kalinauskaite and co-authors (2021), who further developed Schuurman's three-layer model (2015), which is still underutilized as a conceptual model for organising (U)LLs. Second, this study confirms and adds to the current theoretical debate about how to overcome the

issue under study: a change in mindset towards shared ideologies, which requires reviewing the meanings of agency and power. In this effort, we recommend complementing shared ideologies with individual wishes and needs. Likewise, pairing the concepts of "power" and "justification", as we observed that constant pressure to safeguard and legitimise expenditures creates power dynamics in ULLs between stakeholders involved.

5.3 Practical implications

The main practical contribution of this study to ULLs is the emphasis on trust building among stakeholders toward overcoming the issue under study. More specifically, five points emerge: First, public grant providers on various political levels are challenged to rethink their selection criteria for subsidy approvals to guarantee strategic long-term funding in ULLs that can be complemented with project-based private investments. Second and consequently, new ways to measure effectiveness of ULL activities are needed to indicate successes and failures, both quantitative and qualitative, and that allow for deviation on the individual and collective level. In fact, this study shows that increased (social) networks and accumulated learning must be integrated in evaluation criteria. Third, municipalities are challenged to empower ULL initiators politically by reviewing the concepts of "agency" and "power", especially in organic and civic ULLs, as those are active topics that municipalities already treat with concern. Fourth, ULL stakeholders should view the level of abstractness in objectives as facilitators in collaboration by envisioning shared strategic goals, while providing room for individual outcomes to ensure continuous momentum for all stakeholders. While the importance of these anchor points (Leminen et al., 2017) is acknowledged and recognized on the operational level, they have yet to be incorporated on a strategic level. Fifth, the ULL community must become aware of the fragmentation of views about what ULL's are and aren't. Thus, thinking critically about when ULLs are needed will help improve their applicability in practise. Recently, Greve and colleagues (2020) emphasised this as well by exploring the overall landscape of LL research and its potential areas of fragmentation and isolation.

5.4 Limitations and recommendations for further research

We also recognize important limitations to the study.

Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

First, this study was limited to the city of Groningen, and the inclusion of three ULLs indicated as organic, civic, and strategic ULLs. Further research should also focus on comparison between different local contexts, as well as between similar types of ULLs. Second, we held only a limited number of interviews. More experiences from a multitude of people and disciplines should be collected to enrich our understanding of the topic under study. Third, we support with the call of Greve and colleagues (2020) to start using more diverse, as well as quantitative research methods in ULL literature, alongside the often used and in this study applied case study methodology. For example, discourse analysis or ethnographic research designs may help researchers to analyse and experience how (spoken) agency and power is orchestrated in ULL daily practises. Additionally, we call for more research into the power dynamics in ULLs, especially in terms of political power, such as found in studies like Savini and Bertolini (2019). Lastly, we call for more research into the self-sustaining character of ULLs. More specifically, 1) to investigate appropriate ways to embed ULLs in local context needs, by identifying problems and potentials to improve social adoption and ownership of ULLs that help guarantee continuity over time, especially regarding organic and civic ULLs, and, 2) to investigate how ULLs can be self-sustained financially in order to make them less dependent on subsidies, which have led to certain consequences observed and investigated in this study.

Notes:

[1] A *stichting* is a Dutch legal type of organisation that focusses primarily on societal or social goals, rather than monetary profit. A board must be formed in a *stichting*, while a supervisory board is not needed per se. A *stichting* is often funded by donations, loans, or subsidies and does not have members or shareholders.

Previously published

A previous version of this paper was published in the Conference Proceedings of the Digital Living Lab Days 2021 Conference of the European Network of Living Labs. It is available online here: https://issuu.com/enoll/docs/dlld_2021_-_proceedings.

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Stefano Blezer and Nurhan Abujidi

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Stefano Blezer and Nurhan Abujidi

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Urban Living Labs and Transformative Changes: A qualitative study of the triadic relationship between financing, stakeholder roles, and the outcomes of Urban Living Labs in terms of impact creation in the city of Groningen, the Netherlands

Stefano Blezer and Nurhan Abujidi

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A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

“ Innovation is all about people. Innovation thrives when the population is diverse, accepting, and willing to cooperate. ”

Vivek Wadhwa
Author and Entrepreneur

Living lab initiatives attempt to solve challenges by stimulating innovative collaboration and outcomes, which unfold in multifarious activities. This study investigates the progress of Living lab research over time. It explores its current trends, along with methods and tools used by Living labs for user involvement. By employing a two-step approach, the study first presents a bibliometric analysis of 535 publications, including detection of convergence towards areas like the aging problem of societies, smart cities, and overall sustainability. Urban Living lab clusters have been growing rapidly and forming their own research domain. Subsequently, a review of 42 empirical papers explores the methods and tools adopted by Living labs for user involvement during the innovation process. We categorize the methods into the following eight groups: 1) Structured interaction, 2) Flexible interaction, 3) Extended network, 4) Special actors, 5) Learning and engaging, 6) Design approaches; 7) Techniques, 8) Operational guidelines. The study contributes both to theoretical and practice-oriented Living lab research and offers potential support especially to practitioners.

Introduction

The notion of “living labs” has received growing attention in the realm of innovation management. Acting as one form of open innovation that brings external players into the innovation process (Chesbrough et al., 2006), a living lab provides a real-life milieu that stimulates innovative collaboration among people for solving challenges (Westerlund & Leminen, 2011; Almirall et al., 2012). The user-centric approach encourages active participation and integrates users’ knowledge into the value creation process, thereby magnifying innovative competence (Eriksson et al., 2006; Leminen et al., 2012).

After over two decades of development, “living lab” is now a term associated with diverse meanings and research spread into multiple disciplines (Leminen &

Westerlund, 2019). Earlier studies have touched upon numerous aspects such as definitions (Leminen et al., 2012), key principles and components (Bergvall-Kareborn & Stahlbrost, 2009; Westerlund et al., 2018a), users’ roles (Leminen et al., 2015a), and users’ motivation (Bergvall-Kareborn & Stahlbrost, 2009). One of the first living lab literature reviews from Følstad (2008) covered its theoretical foundations, processes, and methods in the Information Communication Technology (ICT) domain, highlighting contextual research and user co-creation as living labs’ unique attributes. Later scholars contributed in drawing a broader picture. For instance, a trend analysis of research topics in living labs (Westerlund et al., 2018b), with a longitudinal review of the living lab movement showed early scattered activities, then the establishment of cross-regional and professional living labs (Leminen & Westerlund, 2019). Some scholars used big data

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

techniques, like bibliometric analysis, or similar ones for mapping a living lab's landscape, thus adding a higher level of understanding such as its intellectual structure (McLoughlin et al., 2018; Greve et al., 2020).

Despite its rapid growth, research on this fairly young phenomenon remains dispersed (Greve et al., 2020). Studies are sparse in areas, applications, publication venues, etc., making it hard to grasp the latest situation. When it comes to user involvement, one unique characteristic of living labs (Bergvall-Kareborn & Stahlbrost, 2009) follows from having inadequate information about how living labs actually involve users (Puerari et al., 2018). Methods and details reflecting their user-centric character remain unclear (Schuurman et al., 2015). Scholars have not yet reached a consensus about models or guidance involving living lab governance and value creation for stakeholders (Westerlund et al., 2018a), which hinders the integration of studies at large. Measuring the effectiveness of user-centric approaches is another underexplored area (Ballon et al., 2018). Meanwhile, wide-ranging practices and methodologies get labelled as "living labs" (Leminen, 2015), making living lab methods and approaches sometimes into just vague words. Here arises the need for more practice-oriented living lab research, both for scholars and practitioners (Westerlund et al., 2018b). On that account, we decided to shed more light on the living lab phenomenon, and aim in this paper to answer the following questions: *i. How has living lab research advanced over time, and what are the current trends? ii. What are the methods and tools used by living labs for user involvement?*

We employ a two-step approach in this literature review. The first section presents a bibliometric analysis of 535 living lab studies from 1991 to 2021 on the topic of developing a consolidated understanding of its research development in terms of publication venues, contributing authors and their collaboration patterns, structures of research domains, and trends. By dividing the twenty years into two periods, we contrast and observe the change and shift of development patterns over time. In the second section, we contribute a further review of 42 empirical papers by identifying eight thematic domains of methods for user involvement in living labs from various aspects, including the format, technique, design approach, and

overarching rules across different stages of the innovation process. We also summarize the tools for user involvement in these studies, in both physical and digital forms. Based on these findings and analyses, we discuss the implications and conclude with suggestions for future exploration.

Living Lab Research Development

The global "living lab movement", especially boosted by European living labs since the establishment of the European Network of Living labs (ENoLL) in 2006, has been drawing attention from researchers and policymakers over the last few years (Hossain et al., 2019; Leminen & Westerlund, 2019). Living lab meanings are manifold: a user-centric methodology (Eriksson et al., 2005), an approach for empowering users (Bergvall-Kareborn & Stahlbrost, 2009), an intermediary for collaboration (Almirall & Wareham, 2011), both the methodology and its structural instrument/agent for user collaboration activities (Almirall et al., 2012), an innovation system/approach/organization that monitors a living social experiment, or just the European living lab movement (Dutilleul et al., 2010).

While scholars differentiate living lab definitions and types, they seek also to establish some common understandings. Bergvall-Kareborn and Stahlbrost (2009) suggested considering the different focus of perspectives under varying circumstances and viewing living lab definitions as complementary. Leminen (2013) highlighted shared elements like "real-life", "user participation", and established "living lab approaches". Others also discuss multiple stakeholders and collaboration during the innovation process (Ballon et al., 2005; Bergvall-Kareborn & Stahlbrost, 2009; Westerlund & Leminen, 2011; Leminen, 2015). Here we refer to the definition by Westerlund and Leminen (2011) of living labs: "Physical regions or virtual realities, or interaction spaces, in which stakeholders from public-private-people partnerships (4Ps) of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts".

Living lab is notably associated with two mainstream research approaches to open innovation and user innovation (Almirall et al., 2012; Schuurman et al., 2015;

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

Hossain et al., 2019). “Open innovation” is about firms opening up in the research and development process, while exchanging knowledge with external parties (Chesbrough, 2003). User innovation emphasizes the importance of users’ heterogeneous needs and innovative abilities (von Hippel, 2005). Discussions of users in innovation trace back to the lead user theory and user-centric innovation, where users are highlighted as a vital source of innovation (von Hippel, 1988, 2005). Living labs, which embrace open innovation and user-centric concepts, provide a network and structured platform for innovative collaboration (Leminen et al., 2012).

Co-creation has also been emphasized as a salient feature of living labs with a locus of living lab experiences (Følstad, 2008; Leminen et al., 2012). We refer also therefore to this definition from Haukipuro et al. (2018) of living labs, which have a “way of working to develop new solutions together with users right from the early stages of development”. Instead of merely being a testing object, users help to fill in blank spots between production and actual user needs (Steen & Van Bueren, 2017). Users as stakeholders actively participate in various forms of activities for exploring new ideas, creating and evaluating new solutions (Ballon et al., 2018). This high-quality knowledge exchange process stimulates the creation of values between firms and users (Pralhad & Ramaswamy, 2004). Such an open approach with progressive engagement have benefited firms by enabling relevant parties to actively contribute to innovation (Almirall & Casadesus-Masanell, 2010). Subsequently, it mitigates potential risks after market launch and leads to further improvement (Ballon & Schuurman, 2015; Schuurman et al., 2016).

Early studies answered “what” questions about living labs, but generally lacked conceptual and methodological knowledge (Bergvall-Kareborn & Stahlbrost, 2009; Leminen & Westerlund, 2017). Studies about methods and activities for co-creation were rather scant. Følstad (2008) listed a few methods for gathering data, such as analysing system logs or automatically collected behavioural data, ethnographic methods, questionnaires, focus groups, and generally, observation, arguing that there is no specific method catered for co-creation yet, instead just for stimulating its potential. Furthermore,

Feurstein et al. (2008) summarized methods according to different innovation stages and grouped them into traditional methods and eCollaboration methods (aided by the Internet), so as to assist firms in choosing and developing suitable methods for user interactions.

The literature more recently is moving toward practice-oriented research about how to design and manage living labs, how to work with actors, and application contexts (Leminen et al., 2015b). Haukipuro et al. (2018) proposed a model of innovation instruments (how the work carries out) to facilitate a co-creation process, suggesting tailored methods for living labs to facilitate collaboration in various environments. Another longitudinal study from Hakkarainen and Hyysalo (2013) explained the intermediary roles of living labs, stating that their intermediation work is wide-ranging, beyond merely facilitation.

Despite an increasing amount of attention received about living labs, researchers point out the reality that users have not yet reached the proclaimed level of co-creation (Greve et al., 2017). Instead of playing active roles as expected, many users remain passive during the innovation process (Nyström et al., 2014), leaving much to explore about actualizing user involvement in living labs. Scholars argue there is no lack of methods and tools, but rather that their usage fails to demonstrate the unique characteristics of living labs, especially considering user involvement (Bergvall-Kareborn & Stahlbrost, 2009). Studies have also shown that the heterogeneity of methods used has made it hard to compare or adopt on a broader scale (Mulder, 2012). The diversity of methods that reside in living labs, their activities, channels of communication, and reporting have hindered the flow of knowledge exchange. Leminen and Westerlund (2017) developed a conceptual framework for understanding the relationship between innovation processes and tools. They argued that the various approaches would have different impacts on the innovation outcomes: the utilization of standardized tools and predefined innovation processes reduces the complicity of innovation, whereas customized tools and iterative innovation processes promote radical innovation development.

Further investigation is needed to integrate knowledge about the methods and tools applied in living lab environments. We therefore continue the exploration

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

here by screening and mapping studies from the field. We follow Merriam-Webster (2021a) which defines “method” as “a procedure or process for attaining an object” and “tool” as “a handheld device that aids in accomplishing a task or something” (Merriam-Webster, 2021b). We also take Følstad’s (2008) concept of “methods” as “standardized procedures for data collection, evaluation or experimentation; typically included as elements in innovation and development processes”.

Method

This study employed a two-step approach: a bibliometric analysis for an overall assessment of literature development, followed by a further review of methods and tools for user involvement in living labs based on empirical studies. To ensure the quality of performing this comprehensive bibliometric analysis, we followed the methods and workflow guidelines from Zupic and Čater (2015). Using data extracted from the first step, we continued with a thematic analysis on the full texts of 42 selected empirical papers on living labs. We adhered to evidence-based research methods (Tranfield et al., 2003) to ensure clarity and coverage in

identifying, selecting, and evaluating data.

The research used two data sources, Web of Science (WoS) and Scopus. Both are commonly used bibliometric databases and have been recognized for their coverage of living lab research (McLoughlin et al., 2018). WoS is more selective on material indexing, while Scopus is more inclusive (Martín-Martín et al., 2018). Past bibliometric analysis studies on living labs chose different databases: Greve et al. (2021) and Greve et al. (2020) used WoS only, while McLoughlin et al. (2018) used Scopus, Google Scholar, and the AIS basket of eight (a term for the eight leading journals from the Association for Information Systems). Our assessment also confirms that WoS and Scopus have different coverage in terms of living lab publications: overlapping, but neither is inclusive (Burnham, 2006). WoS includes more, but not all living lab papers from The Technology Innovation Management Review (TIM Review), a journal that publishes the most living lab papers. Scopus also covers documents that WoS does not capture, for example, some from Sustainability. Taken overall, they complement each other. Thus, we combined both to get broader access to living lab literature.

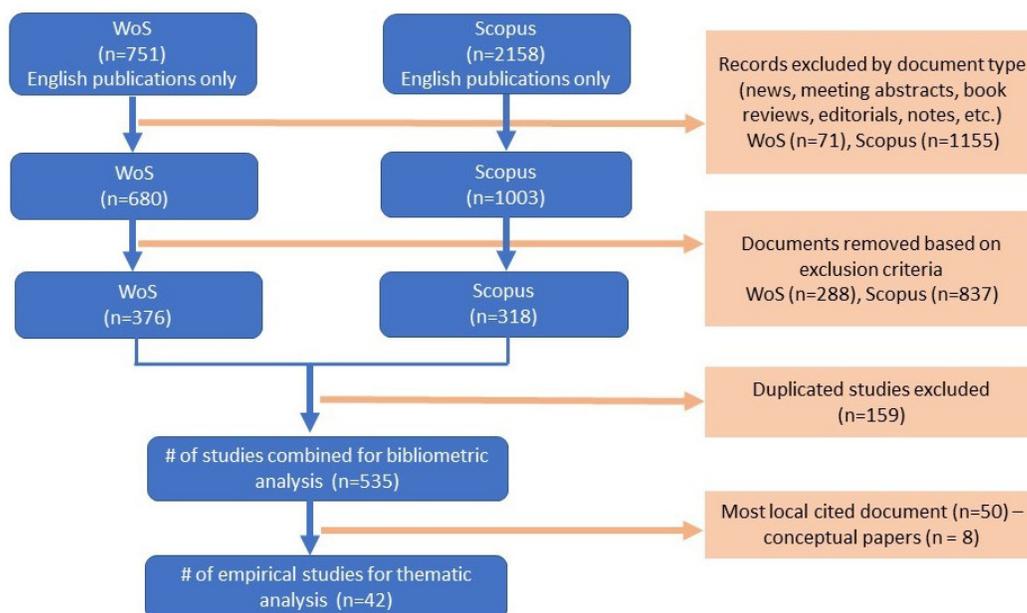


Figure 1. Methodological Approach

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

We then developed the search string and restrictions by referring to several literature reviews on living labs (Schuurman et al., 2015; McLoughlin et al., 2018; Greve et al., 2020). They are: “living lab*” OR “livinglab” OR “living laborator*” that appears in the title, abstract, or author keywords of documents. The * sign was used to capture words in their plural forms. Publication types were restricted to peer-reviewed journal articles, books, and book chapters in English across all years. A search ran separately on WoS and Scopus web portals in January 2021, with 751 and 2,158 documents returned respectively. The exclusion criteria were: 1. Scientific-experiment labs analysing collected user data, but which did not involve users in the process, 2. Labs in the context of nature, living animals, ecology terms, not focused on human beings, 3. Metaphors for a region, country, or society only, and, 4. Living lab as an approach for solving certain social/experimental problems, but with no users involved.

The screening process took place on both portals (Figure 1), where the authors read the titles, keywords, abstracts, and even the content of the documents. The authors discussed and agreed on the search strings,

exclusion criteria, and other issues related to paper selections. After the screening, there were 376 documents from WoS and 318 from Scopus. We downloaded the data and loaded it into the software RStudio installed with a bibliometrix package, which combined both and removed 159 duplicates. We then reached the final 535 documents, consisting of 474 journal articles, 5 books, and 56 book chapters. We ran this combined data file on Biblioshiny, a web-based interface of R-package for bibliometric analyses, following the bibliometric method: citation, co-citation, co-author, bibliographic coupling, and co-word (Aria & Cuccurullo, 2017). The analyses mapped intellectual streams and approaches, generating a visualization of patterns, distribution, domains, and trends.

Step two, the review started with a list of the most local cited documents from Biblioshiny, following the results from the co-citation analysis (when two units are both cited by a third unit). Biblioshiny can use as a unit of analysis the document, author, and journal (Aria & Cuccurullo, 2017). We took document co-citation since we were interested in reading the full text of these documents. These co-cited documents are listed based

Table 1. 20 most relevant sources

<i>Source</i>	<i>Type</i>	<i>No. of documents</i>
The Technology Innovation Management Review	Journal	43
Sustainability	Journal	30
Urban Living Labs: Experimenting with City Futures	Book	13
The Journal of Cleaner Production	Journal	10
Info: The journal of policy, regulation and strategy for telecommunications, information and media (Now: Digital Policy, Regulation and Governance)	Journal	7
Urban Planning	Journal	7
Innovation and Research in BioMedical engineering	Journal	6
International Journal of Sustainability in Higher Education	Journal	5
Living Labs: Design and Assessment of Sustainable Living	Book	5
ACM Transactions on Computer-Human Interaction	Journal	4

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

on the number of citations received within the network. “Local” means within the sample collection, and “global” means the entire database collection (Aria & Cuccurullo, 2017). The global citation generally is a higher number, but tends to return documents from all disciplines, not necessarily living lab focused. Using citation as the selection criterion, which often appears in the format of “top-N” lists of units, helps detect the influencing works and common practices in the field (Zupic & Čater, 2015). McLoughlin et al. (2018) extracted the top 60 conceptual & methodological living lab papers based on citation count for their citation analysis, and Greve et al. (2020) performed co-citation analyses on the 41 most cited articles within its databases (297 articles). Overall, the local citation numbers of these 535 documents were much smaller than their global citation numbers, which can be explained by the diversity of documents within the collection. We shortlisted the 50 documents with the most local citations, and they turned out to be journal papers only; eight conceptual and 42 empirical. We performed a thematic analysis on the empirical papers, searching for words associated with method/methodology/tool, identifying and coding the relevant content based on definitions and contexts, grouping content by combining codes, and developing themes (Braun & Clarke, 2006; Clarke & Braun, 2017).

Findings

We start by presenting the findings from the bibliometric analysis. The 535 documents were published between January 1991 and January 2021. 80% are from 2015 onwards, which reflects the recently rapid growth of living lab research. They are from 324 sources: journals articles (474), books (5), and book chapters (56). Table 1 lists ten sources with the most publications, with TIM Review and Sustainability the two journals having the most living lab articles published. There were two books: one about Urban living labs (Marvin et al., 2018) and one about living labs for sustainable living (Keyson et al., 2017). A measurement by g-index, which measures a publication’s global citation impact, wherein the top g articles receive a total of at least g² citations (Egghe, 2006), shows that journals like TIM Review (16), Journal of Cleaner Production (10), Sustainability (8), and Digital Policy, Regulation, and Governance (7) are also the most influential journals for living lab research. It is worth noticing that there are fewer living labs papers published in other journals, or in journals with high rankings, referencing the Academic Journal Guide 2021 (Jena, 2021). The relatively limited quantity of publication outlets echoes prior findings that living lab studies remain in a small community of dissemination and authors in this field (McLoughlin et al., 2018; Greve et al., 2021).

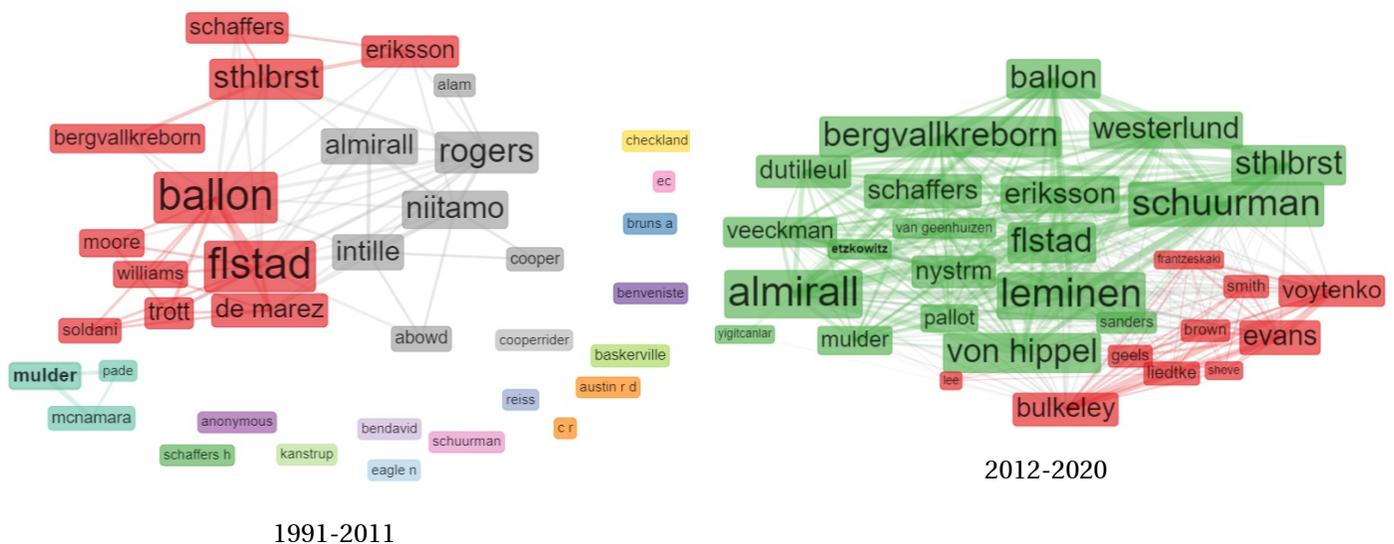


Figure 2. Co-citation of authors

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

To have a better understanding of the growth in publication, we compare living lab studies by dividing the twenty years into two periods: 1991-2011 and 2011-2020. 2021 was excluded as the data were up to January 22 only. Figure 2 shows the results in terms of authors from a co-citation analysis, which is one popular method used for quantified evaluation involving the influence of works and interconnections among a network (Zupic & Čater, 2015). Mapping the co-citation patterns (relationships among the network) over some time also helps to detect the shift in research ideas and methods used (Small, 1973). When two authors are cited by a third one, a connection is established and a co-citation network is formed (Aria & Cuccurullo, 2017). The thickness of the lines represents the level of connection through publications. During 1991-2011, there were 25 scattered clusters with only a few key authors citing each other. Two main clusters formed during 2012-2020, with the larger one a continuous stream for living labs, and a new one focusing specifically on urban living labs, with researchers like James Evans, Harriet Bulkeley, and Yuliya Voytenko.

Figure 3 illustrates the results from a collaboration network analysis that measured co-authorships among authors (Zupic & Čater, 2015): the 41 clusters during 1991-2011 were divergent, with very few connected nodes, which means few collaboration groups among

authors. The 16 clusters in 2012-2020 exhibit more convergence with several collaborative groups forming around a few key contributors, like Esteve Almirall, Seppo Leminen, and Dimitri Schuurman. There are many more, and different key authors in the recent period, suggesting a fast growth in a short time. Still, the sizes of these groups are relatively compact. The distribution is sparse with rather weak connections, along with long distances among groups, which reveals still immaturity of living lab research development, despite the growth of living lab researcher strength and collaboration.

To estimate the relationships and conceptual structures of the various research domains, we investigated the co-occurrence network, measured by the appearance of keywords (co-word) or other terms in the documents (Zupic & Čater, 2015). The period of 1991-2011 consisted of 23 diverse research domains clusters (Figure 4). Major themes like “innovation”, “living lab”, “information technology”, “open innovation”, “user-centric”, “approach”, indicate the founding topics during the early conceptual phase of living lab research. The rest are tiny and isolated clusters. The period 2012-2020 has three clusters: innovation, human, and living lab (about its design and concepts). The last two have gained more consensus, as in a more concise and interconnected form. The innovation cluster has wide-ranging sub-

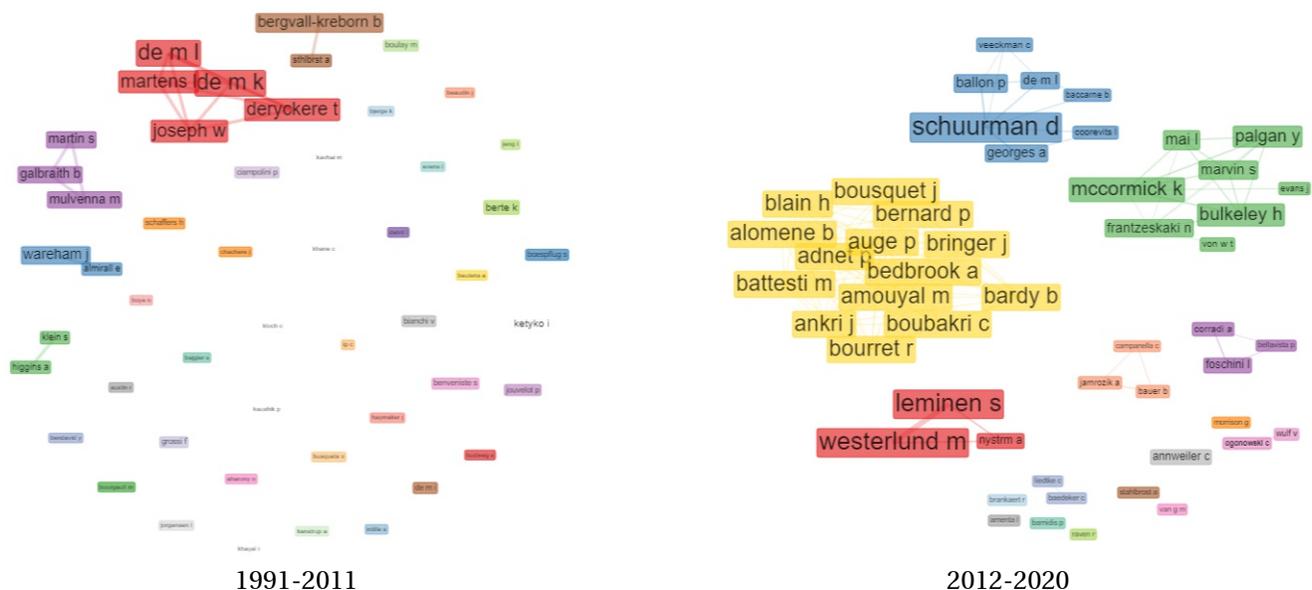


Figure 3. Collaboration network

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

topics from sectors like energy, education, urban, city/cities, to topics like governance, framework, and sustainability, with sustainability and smart city being the two most extensive and interconnected themes. This echoes with the suggestion from Hossain et al. (2019) that “sustainability” is often connected with the topic of “smart city”, with the latter one providing the contextual settings. Interestingly, though “human” (as a subject) is one of the most frequently occurring keywords, “user”, or “user innovation” that point to users’ roles, are not among the most frequent terms, nor is “stakeholder”. “Co-creation”, “open innovation”, and “methodology” (or “method”) do not occur as frequently in the recent period, and tended to become outlying keywords in the newer living lab cluster. As for methods, this might be partly explained by the fact that they occur in their exact form, like workshops, focus groups, questionnaires, activities, etc., rather than as a topic at an integrative level.

By matching the year and frequency of keywords’ occurrence, it shows the trending topics over time (Figure 5). In the last decade, living labs research has extended beyond the ICT domain to more diverse disciplines, with several evident topics like sustainability, smart city, urban, and ageing population. Though the smart city topic has been gaining attention for a while, its surge began in 2018. Similar topics like urban planning and urban development, sustainability and smart city, climate change, and transition emerge around each other.

Topics related to the ageing population have clearly earned great emphasis in recent years.

To further explore, we ran a bibliographic coupling analysis, which examines the references shared by two documents (opposite to co-citation), checks the similarities, and depicts the latest research trend (Zupic & Čater, 2015; Aria & Cuccurullo, 2017). Figure 6 shows three main clusters during the period 2012-2020: Cluster 1, Technology Innovation (the “main school” of living lab research), along with two Urban Living lab clusters, Cluster 2 led by work from authors Voytenko et al. (2016), and Cluster 3 from work by Menny et al. (2018). The variety in urban living labs perhaps explains the existence of different working groups. We should note the heavily overlapping areas that suggest strong interconnections among studies. Clusters 2 & 3 are distant from Cluster 1, which implies that urban living lab research is probably growing out of the “main school” to form its own cluster(s). This aligns with our findings from co-citation and co-word analysis. The existence of several other less connected clusters also acknowledges multi-directional research development in the urban living lab domain.

We now focus on the review of 42 empirical articles for identifying methods and tools for user involvement. Among them, 15 papers were from the urban living labs field, making it the largest field. The rest were from areas: ICT (8), health (4), multiple - covering more than one field (6), others (9). Publication years range from

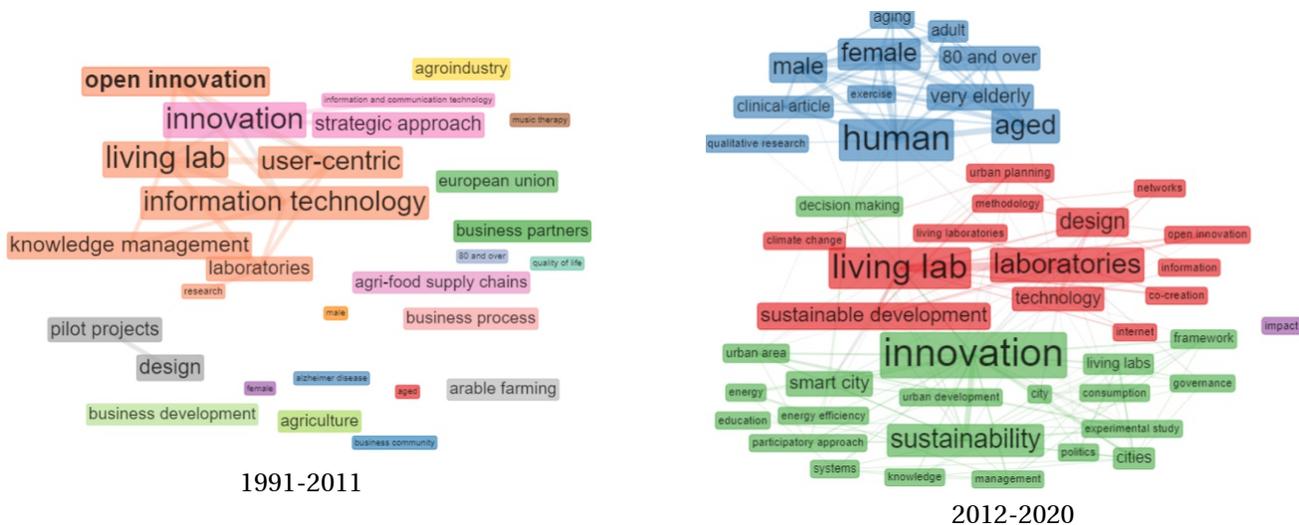


Figure 4. Co-occurrence network

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

1991 to 2019: one is from 1991, and 41 are between 2010 and 2019. Following the definitions of “method” and “tool” from Merriam-Webster (2021a, 2021b) and Følstad (2008) above, we conducted coding and grouping, then subsequently identified eight thematic domains in terms of methods. We adopted the first two from Leminen et al. (2015b) and generated the rest through analysis. Table 2 summarizes the findings (with a full list of papers in Appendix 1):

- 1) Structured interaction: formalized activities,
- 2) Flexible interaction: encouraging more interactions and flexibility,
- 3) Extended network: reaching out to broader networks for awareness and contact,
- 4) Special actors: using active players to engage the rest of the population,

- 5) Learning and engaging: creating an inclusive environment,
- 6) Design approaches: systemic methodologies for designing activities,
- 7) Techniques: employing particular tasks or procedures from other fields,
- 8) Operational guidelines: overarching and underlying rules for facilitating user involvement.

Structured interaction and flexible interaction are the two dominant types in terms of frequency of mention. The former refers to more formal and organized in predefined formats, such as observation, survey, user testing, etc. Additionally, it includes self-reporting methods, with users participating less interactively, and information collected through mediums like diaries, sensors, and activity logs. Flexible interactions

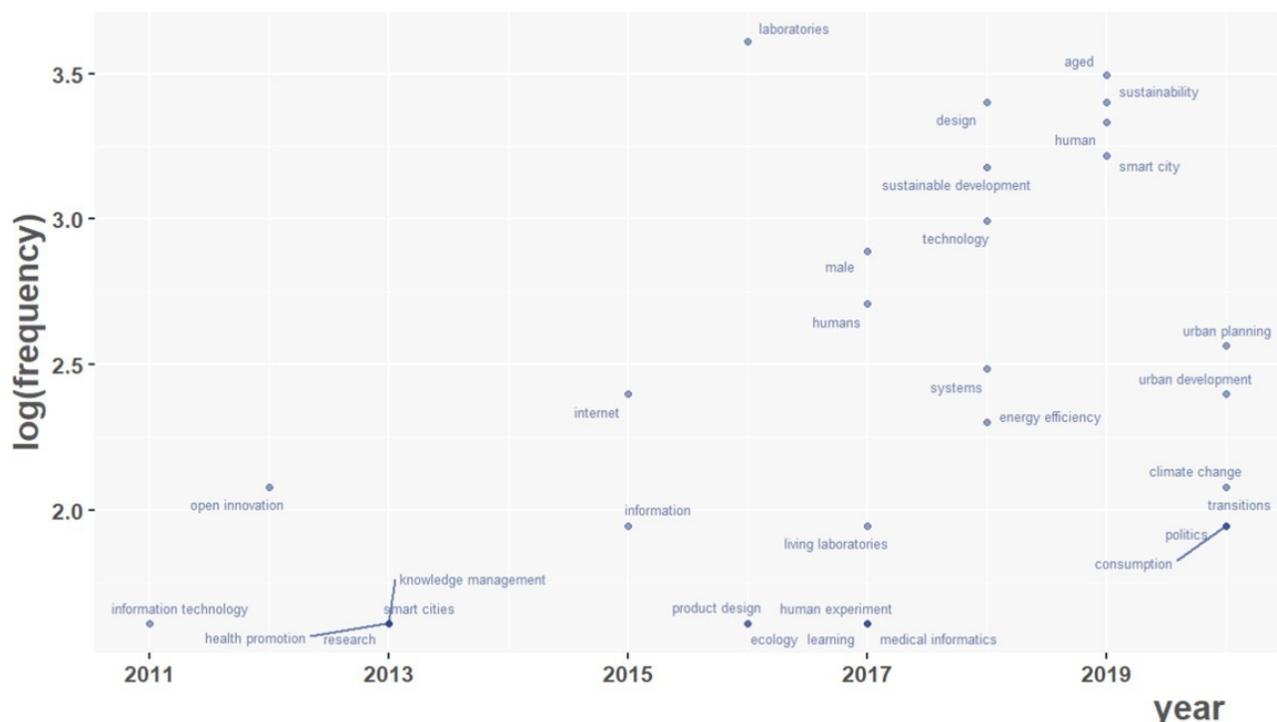


Figure 5. Trend topics

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

tend to follow some guidelines, while having more freedom in arrangement and flexibility for interactions between organizers and participants, as well as among participants themselves. Among these flexible interaction methods, interviews, co-creation workshops, and user meetings are the most popular. The extended network highlights the importance of reaching out to a broad network through building or engaging active user communities, attracting public attention, and encouraging participation from users and related personnel. Having special actors echoes lead user theory by appointing active players as early movers and contact points among users. Learning and engaging investigates how to connect users in the process, mentioning methods like innovation camp, tailoring, team building, user training, and fun tasks that motivate users. Design approaches take more systematic design perspectives through participatory design, bottom-up approaches, design thinking, etc. Techniques involve using a few specific tasks or procedures that have certain formats and have been

practiced in other fields, for example, storytelling, hackathons, round tables, World Café, etc. The last one, operational guidelines is more about general rules than specific methods. Aligning with the suggestions from Feurstein et al. (2008), we note one of the most mentioned guidelines is the multi-methodological approach that adopts differentiated methods at various stages of innovation for effective user involvement.

Table 3 summarizes the tools, which happen in both physical and digital formats. Digital tools like mobile applications and online platforms are the majority, while physical tools are less mentioned. Tools are used jointly with methods; thus, they are generally embedded in the methods section, rather than being a separate topic in these papers. They often come in packages such as websites, applications, and social media. There was much emphasis on methods and their applications in these papers. The tools should be examined along with their corresponding application method.

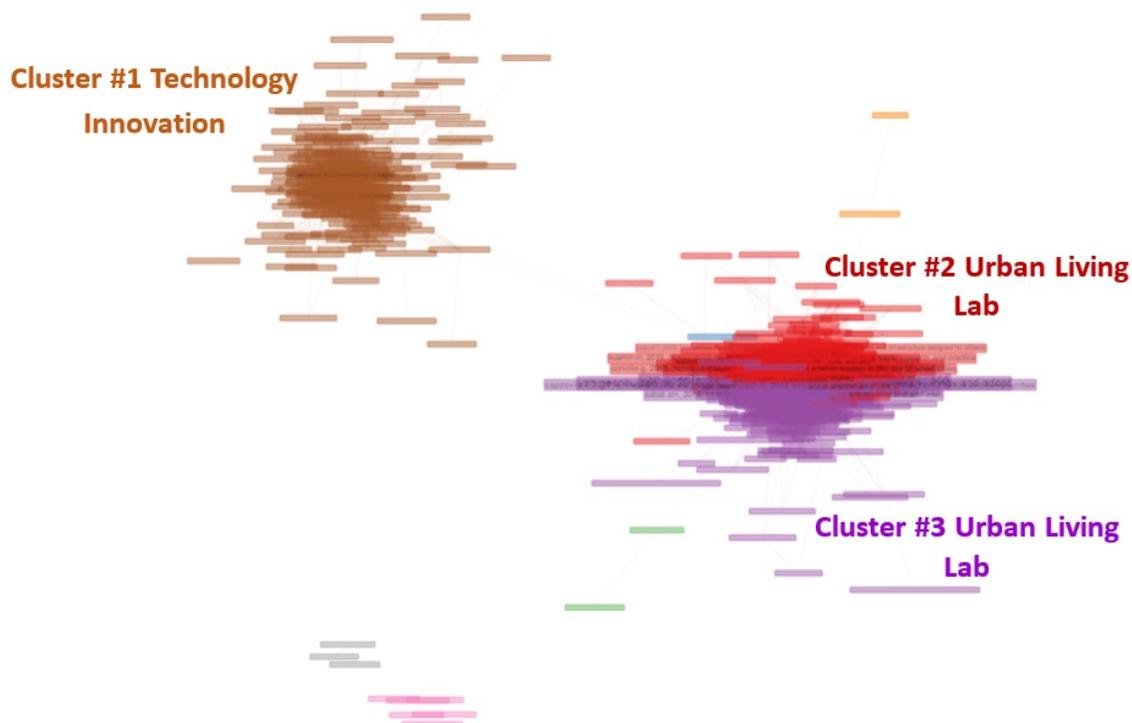


Figure 6. Bibliographic coupling clusters

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

Table 2. Summary of methods used for user involvement in Living labs

Thematic Domain	Method	Further Information	Document*
Structured interaction	Observation	Contextual observation, in situ monitoring, participatory observation	7, 11, 13, 14, 15, 19, 26, 27, 29, 30, 36, 39, 47
	Survey		7, 11, 15, 22, 27, 28, 30, 33, 45, 47
	Usability testing	Using prototypes or mock-ups to see if users can use the product	12, 36, 40, 43
	User testing	In a controlled environment or field trials; intervention during testing; long-term testing under realistic circumstance	7, 11, 12, 13, 14, 19, 23, 25, 26, 27, 29, 30, 36, 37, 39, 40, 43, 45, 50
	Self-reporting methods	diaries, sensors, logs	7, 11, 15, 19, 27, 29, 37, 39, 45
Flexible interaction	Interview, including focus group	Typically, in face-to-face format. (Note: interview can be a structured interaction too)	7, 9, 11, 14, 17, 26, 27, 30, 34, 36, 37, 40, 43, 45, 47
	Co-creation workshop	Fab lab is included here	7, 9, 11, 13, 14, 18, 19, 22, 24, 26, 30, 31, 34, 36, 37, 39, 40, 45
	Co-joint analysis		40
	Follow-up visit		39
	Social/co-working space	Specially for long-term collaboration	37, 41
	User meeting	Discussion/sparring/ feedback	11, 13, 14, 22, 25, 45
	User experience field studies	Studying user experiences in their daily life contexts	27
Extended network	"Living room" for users	Activities that people in the community can join, such as parties	28
	Community workshop	An application of the formative invention method Change Laboratory	9
	Create/use local user community		9, 14, 17, 19, 29, 36, 47
	Inter-disciplinary groups		40
	Public awareness campaigns		11
	Broader network of participation	Extending to personnel related to users; extended geographical distance or disciplines	2, 6, 11
Special actors	Ambassador		11
	Helpdesk or "repairer"	Accessible to users for assistance	12, 37
	Lead user		2, 36, 40
	Mediator	A single person that enlists participants	37
	Prime mover	A person who has strong interest in the project and acts as a contact person	37
Learning and engaging	Idea competition/campaign		11, 43
	Tailoring	Tailer-made approach for users at different skill levels	13
	Team building		14
	User training		13, 25
	"Having fun"	Including fun tasks that challenge users or trigger their curiosity	12, 22

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

Table 2. Summary of methods used for user involvement in Living labs (cont'd)

Design approaches	Bottom-up approach	Informal; no imposed structure; support local champions	14
	Design thinking	Collecting some existing data and analysing it in a new way to develop innovative and flexible solutions	18
	Design-driven focus approach	Participants use the focal technology as they see fit without restrictions or prescriptions; allows open-ended insights into the context	44
	Participatory design	Also referred to as "co-design"	19, 30, 37, 41
	Practice-oriented design	Collaborative processes of discursive analysis and experimentation in daily life, shifting focus from products to practices	24
Techniques	Storytelling		18, 36, 40
	Hackathon		41
	Cultural probe		26
	MoSCoW method	For generating user stories: "Must Have, Should Have, Could Have, Won't Have this time"	43
	Round table		26
	Serious game simulation		26
	Virtual engagement/ community		6, 11, 40
	World Café	A conversational and interactive event (Brown & Isaacs, 2005)	45
Operational guidelines	Iterative approach	Iterative testing cycles for quick response and improvement	19, 22
	The "living" aspect	Sharing of development status and reflections; users can check the real-time information	9, 19
	Combined tools	Combining face-to-face methods and digital tools	45
	Communication	Clear and personal communication; clear feedback loop	12, 22
	Testing initiation process	Clear and straight forward testing initiation process	12
	Multi-methodological approach	Using differentiated methods at different stages of innovation	7, 11, 19, 23, 2, 30, 39, 40, 45
	Incentives	Providing incentives to encourage test users to complete tasks	12
	The benefits & co-creation aspect	Motivating users by letting them know that their contributions impact the innovation	12

* Documents are listed by their sequence numbers. See Appendix for the full list.

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

Discussion and Conclusion

Our study analysed living lab research with an overview of its history and current trends. It presents a gap-filling summary of methods and tools employed for user involvement. Though living lab publications have increased rapidly in recent years, especially from 2015 onwards, it is still a new stream that is loosely connected with the leading publication channels in the field of innovation management. This limits the level of impact it could potentially make. Scholars like Greve et al. (2021) have mentioned the recent entry of living lab studies into some high-ranking publication outlets for innovation management studies, which could show some positive signs of progress. The living lab research network has transformed from only a few individuals and loosely allied groups, into several rising clusters. This is likely to stimulate the growth of the living labs research community and provide a basis for further studies.

Yet, meanwhile there is still no strong evidence for one or more dominant groups to act as a “core cluster network” (McLoughlin et al., 2018). The small-scale contributing scholars and collaborative clusters, with comparatively weak interconnections imply that living

lab research is not yet full-grown. While living lab research topics are multi-disciplinary with various applications, they show some convergence on areas like the ageing population, smart cities, and sustainability. The last two are often interconnected and each associates with several sub-topics, thus confirming the earlier findings from McLoughlin et al. (2018) and Westerlund et al. (2018b).

There is a rising interest in urban living labs, which refers to “a form of collective urban governance and experimentation to address sustainability issues created by urbanization” (Veeckman & Temmerman, 2021). They share many characteristics with living labs, and focus on finding solutions for urban substantiality using a bottom-up approach with stakeholders that include citizens, public and private organizations, etc. (Juujärvi & Lund, 2016). Citizens are active users contributing through collaboration with other stakeholders and experts under the larger urban setting (Lehmann et al., 2015). “Urban living lab” has grown into an umbrella name for many similar activities, possibly due to the diversity within its domain. The research clusters show more divergence than the “main school” of living lab research, signalling that they are forming a distinctive research domain. Urban

Table 3. Tools used for user involvement

Tools	Documents*
Blog (community blog/user group blog)	14
Call/text message/chat/email	11, 18
Diary	11, 19, 27, 37, 45
Feedback form	40, 45
Feedback software (interactive technology)	39
Individual workbook	24
Mobile application	14,15, 19, 34, 37, 44, 45
Multi-media tool (video conferencing)	6, 9, 14, 45
Newsletter	22
Shared web portal for co-creation and/or reporting	11, 14, 17, 18, 22, 28, 34, 45
Postal service	14
Sensor toolkit (data logger)	7, 15, 29, 39
Service point (physical or remote)	18
Social media platform (e.g., Facebook, Twitter, Instagram)	6, 22, 28
Website	6, 19

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

living lab researchers and practitioners are actively investigating and extracting methodologies for user involvement from the living lab research cluster (Steen & Van Bueren, 2017), while contributing back to the pool of living lab studies with knowledge gained from their thriving fields.

Meanwhile, a lack of solid endorsement for living lab's theoretical foundations remains, posing challenges to its integration into the mainstream innovation literature. Our study agrees with the need for more evident support to the conceptual roots and salient characteristics of living labs, such as co-creation or user-centric approaches (Schuurman et al., 2015). When moving toward practice-oriented research (Westerlund et al., 2018b), researchers should justify living lab concepts and approaches claimed in their empirical research. Importantly, a need for more well-rounded research is evident that bridges different perspectives of living lab methodologies to enable the sharing of empirical knowledge and accommodate researchers and practitioners in developing a more comprehensive understanding before drilling down to the practical level. This study answers the call for research on methods involving user involvement in living labs.

By drawing a list of methods and tools from some highly cited empirical papers, we hope to contribute to building an overall picture of the current and common approaches in facilitating co-creation, while touching upon various aspects such as the format, technique, systematic design approach, guidelines, etc. This is by no mean an exhaustive list, nor the invention of new methods, since popular ones like surveys, interviews, observation, workshops, and testing are already common in other fields. It is not about promoting certain standardized methods either because adoption or customization requires a deeper understanding of the methods and applicable circumstances. Co-creation is not a single-level activity, but rather a combination of multiple levels of user involvement (Menny et al., 2018), embedded in the design and implementation of living labs. This could be one entry point for further research and references for practitioners in complex practice areas. Having in-depth knowledge about the methods and tools could be beneficial for practitioners to assess, replicate, and improve living lab activities, while also assisting

policymakers in making better decisions for fostering living labs and enhancing collaborations. Just as urban living labs have shown their notable contribution and potential in developing methods and tools for user involvement, the synthesis of a flourishing living lab with contributions from different disciplines has become essential.

Limitations and Future Research

This study analysed publications collected from two scholarly databases. Future research can consider expanding the research scope in terms of sources, document types, and volume. The selected empirical papers were only up to 2019, as it takes time for new ones to gain citations. Thus, using citation as the selection basis might have filtered out some recent publications or novel methods in the first place. Future studies should consider adopting different methods for paper selection. Meanwhile, many activities (including user collaborations) have shifted online since the pandemic began in 2020 (Westerlund et al., 2021). It would be interesting to review recent papers to investigate the shift in patterns and effectiveness regarding digital inclusion. Furthermore, these methods and tools are a means for actualizing the co-creation process. What matters more is to apply the suitable ones in their contextual settings, which could also be explored further.

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

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A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

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Judy Hong Huang and Elisa Thomas

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About the Authors

Judy Hong Huang is a Ph.D. candidate at the Business School, University of Stavanger, Norway. She works with a research project named “Releasing the Power of Users - articulating user interests to accelerate new innovative pathways in digital health and welfare sector”. It is a four-year international project funded by the Norwegian Research Council. Her study belongs to its work package 2, “Creating boundary innovation space” with a special interest in living labs, their user-driven or user-inspired innovations, and methods for user involvement.

Elisa Thomas is an Associate Professor at Nord University (Norway) and an Adjunct Associate Professor at the University of Stavanger (Norway). She is a leader of the Academic Division in Competences, Behaviour, and Culture for Innovation at the Brazilian Academy of Management (ANPAD), and a leader of the Special Interest Group on Responsible Innovation at the International Society for Professional Innovation Management (ISPIM). Her research interests include entrepreneurship and innovation ecosystems, the role of universities in regional development, start-up incubators, technology parks, and open innovation intermediaries.

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Keywords: Literature review, bibliometric analysis, Living lab, user involvement, co-creation

A Review of Living Lab Research and Methods for User Involvement

Judy Hong Huang and Elisa Thomas

Appendix 1. List of most local cited papers

S/ N	Paper
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