Living Labs as boundary-spanners between Triple Helix actors

van Geenhuizen, Marina

DOI
10.17477/jcea.2016.15.1.078

Publication date
2016

Document Version
Final published version

Published in
Journal of Contemporary Eastern Asia

Journal of Contemporary Eastern Asia
ISSN 2383-9449

Marina van Geenhuizen

Living Labs as boundary-spanners between Triple Helix actors

Journal of Contemporary Eastern Asia Vol. 15, No. 1: 78-97

Journal abbreviation: J. Contemp. East. Asia

Stable URL: http://eastasia.yu.ac.kr/documents/ Geenhuizen_15_1.pdf
http://dx.doi.org/10.17477/jcea.2016.15.1.078

Journal of Contemporary Eastern Asia Vol. 15, No. 1: 78-97
http://dx.doi.org/10.17477/jcea.2016.15.1.078

Living Labs as boundary-spanners between Triple Helix actors

Marina van Geenhuizen[1]

Living labs are an increasingly popular methodology to enhance innovation. Living labs aim to span boundaries between different organizations, among others Triple helix actors, by acting as a network organization typically in a real-life environment to foster co-creation by user-groups. This paper presents critical factors of Living labs in boundary-spanning between Triple Helix actors. Derived from a mixed-method approach and applications in the healthcare sector, the three main critical factors turn out to be 1) an adequate user-group selection and involvement, specifically a rich interaction and absorption of its results, 2) a balanced involvement of all relevant actors, and 3) a sufficient (early) attention for values, both values of user-groups and values of the management. People-oriented Living labs tend to differ from institution-oriented Living labs regarding these critical factors. Further, universities tend to take on diverse roles and strength of involvement, while the business sector tends to be actively involved only if this has been set as an explicit aim at start. The paper closes with a summary and future research paths.

Keywords: triple helix, living labs, boundary-spanning, user-groups, co-creation

Triple Helix and Living Labs

The future of many countries today is seen as dependent upon opportunities of science, engineering and technology. This is specifically true in the European Union, where these assets are seen as contributing to solve the grand societal challenges and increasing competitiveness of the European economy (EC, 2014). The Triple Helix or - Quadruple Helix including user groups - is an important part of this attention when it comes to application of science and technology. The concept of Triple Helix was introduced in the mid-1990s by Etzkowitz and Leydesdorff (1998) and marked the shift from an industry-government dominated industrial society to a more pronounced position of universities in a triadic relationship of university-industry-government in a knowledge-based society. In an ideal model, a certain hybridization of tasks between universities, the business world and governments provides the best potentials for innovation and economic

[1] Technology, Policy and Management, Delft University of Technology, Netherlands

growth. This may include collaborative daily activities but also alignment in medium-term agenda-setting concerning research programs with businesses and cities/regions.

In many economies and societies, the Triple Helix model, however, does not work satisfactory due to the influence of barriers between the actors involved (Geuna and Muscio, 2009; Bruneel et al., 2010; van Geenhuizen, 2013) and lack of using interfaces (Leydesdorff and Meyer, 2007). Though improvement has been observed, Triple Helix interaction and knowledge flows are still facing a division into two 'realms', the research community and the business community. Barriers preventing knowledge flow and collaboration may be related to task conflicts and relationship conflicts (Ranga and Etzkowitz, 2013). Task conflicts originate from diverse aims in knowledge production and related time-horizons. Universities use time horizons of four years (PhD research) and aim at a scientific output and recognition among peers in the first place, while the business world avoids starting research or ends it if no commercial opportunities are perceived. Besides, they employ different attitudes on disclosure of research results (IP) (Bruneel et al., 2010). Relationship conflicts are stronger connected to personal affinity and preferences. Thus, a weak affinity of university researchers with applied studies and with the market may act as a main barrier causing delay or failure of commercialization (Van Geenhuizen, 2013). We mention also as barriers: different culture and 'language' and different technology level, but also different power positions, like between SMEs and multinational companies (MNCs). In some developing countries with rigid fragmentation and less flexible institutions, Triple Helix interaction and hybridization of roles, may even be difficult to get started (Saad and Sawdie, 2011; Philips, 2014).

The presence of manifold barriers calls for the implementation of models of boundary-spanning. While much attention has been paid to intermediaries like university transfer offices, knowledge intensive service firms (KIBS), knowledge brokers and knowledge platforms, Living labs have largely remained out of this range (Howells, 2006; Todeva, 2013; Meyer and Kearns, 2013; Schlierf and Meyer, 2013; Van Geenhuizen, 2014). Living labs are increasingly popular in enhancing innovation in various practical areas, such as sustainable energy, housing, healthcare, information and communication technology (ICT) and transport. They can be seen as temporary network organizations in which Triple Helix actors and user-groups are brought together in a real-life environment, with the aim to transform inventions more efficiently and introduce them quicker to market or application in society. Living labs have recently become the subject of systematic research (e.g., Almirall et al., 2012; Leminen and Westerlund, 2012, Leminen, 2013; Ståhlbrost, 2012; Dubé et al., 2013; Sauer, 2013). However, thus far, relatively little attention has been paid to critical factors in the management of Living labs and their boundary-spanning activity, which can be ascribed to the lack of a uniform definition and the often fuzzy extension into different directions (Leminen, 2013; Nystrøm et al., 2014).

This paper is relatively new in that it addresses the knowledge gap of critical factors, using a narrow conceptualization of Living labs in boundary-spanning activities in a Triple/Quadruple Helix context. Against the above background, the research questions of the paper are as follows:

- What are the features of Living labs and how do they act as boundary-spanners between Triple/Quadruple Helix actors?
- Which critical factors tend to influence this boundary-spanning activity?

The paper is structured in five sections. In section 2, the concepts of boundary-spanning, Living labs and co-creation are characterized on the basis of literature. The methodology of the study is explained in section 3, including a preliminary framework of critical factors of Living labs as boundary-spanners. This framework is explored using four case studies in section 4. The paper closes in section 5 with a discussion of the results and future research paths.

Boundary Spanning and Living Labs

Boundary-spanning

In innovation systems, the main aim of intermediation or boundary-spanning can be described as to alleviate bottlenecks and enhance a good flow of knowledge between different 'realms', by providing value-added activities/services to individual actors or organizations. We perceive boundary spanning, however, as a broad set of activities matching with Howells' definition of an intermediary as an organization that acts as an agent or broker in any aspect of the innovation process between two or more parties (2006: 720), thus also including enhancing of collaborative learning and co-creation. Further, the focus of boundary-spanning may be on individual persons, teams or organizations (networks) or on all three (Williams, 2002; Marrone et al., 2007; Harvey et al., 2014). In this paper, we focus on the organization level with Living labs as temporary network organizations. With regard to position in the system, intermediaries or boundary-spanners might locate in-house at one of the actors, like transfer offices and R&D labs at university that undertake specific boundary-organization activity (Mørk et al., 2012). Or intermediaries are somewhere in-between organizations and independent as a genuine 'third party'. In our study, the selected Living labs are not part of the university, but part of the academic hospital and more independent ones somewhere in-between different organizations.

Concerning the type of boundary-spanning activities, we take the stance that these include all processes needed to achieve collaborative learning (co-creation) and innovation, ranging from connecting relevant actors (particularly users) and creation of a common 'language', trust and common interest and community, to collaborative learning and absorption of the outcomes in development and design (Williams, 2002; de Moor et al., 2010).

2.2 Living labs

Living labs originated in the early 2000s when William Mitchell first practiced them at Massachusetts Institute of Technology, by moving research activities from research laboratories to in vivo settings, making it possible to monitor user interaction with innovations in real life circumstances. A major contribution to the development of the Living labs concept came actually earlier in time from research on users/customers as an important origin of innovation (Von Hippel, 1986, 2005). Ideas on user-led innovation and the customer-active paradigm have fostered models involving the co-creation of value by companies, researchers and customers (Pralahad and Ramaswamy, 2004).

At the same time, the Living lab concept was 'fuelled' by models of open innovation (Chesbrough, 2003; Chesbrough et al., 2006; Enkel et al., 2009), in which large and small firms work together with research institutes in R&D and share the results under certain conditions, while providing benefits such as cost savings, increased user-value and a better (quicker) innovation performance and market access. All these developments led to a shift of innovation to a network model consisting of different partners, with an emphasis on involving user-groups early in the process and more actively (Vanhaverbeke, 2007). In Europe, most experience with the design and management of Living labs has been gained by Living labs as members of the European Network of Living Labs (ENoLL), a platform established in Finland in 2006, which fosters the introduction of mainly ICT-based innovations in European societies (EC, 2009; ENoLL, 2014).

Furthermore, recently, the model of innovation in Europe started to change once more, resulting in a more prominent position of the public sector and civic society, this in relation to the need to solve various large societal challenges, as indicated by the European Commission in the document Horizon 2020 (2011). This has also 'resonated' in new ideas forwarded by the European Commission on conducting research, placing a stronger emphasis on the social engagement of universities (e.g. Breznitz and Feldman, 2012; Goddard and Valance, 2013; Trencher et al., 2014). According to this line, the recent proposal of 'Science 2.0' (European Commission) is more open in terms of its participants, it is more user-driven and more data-intensive, and it develops more quickly, etc., however, this renewed vision is still in the process of 'consultation' of important stakeholders in Europe.

Living labs has remained a 'fuzzy' concept, ever since it was introduced. Broadly speaking, there are two conceptualizations of Living labs in existing literature (Følstad, 2008; Guldemond and Van Geenhuizen, 2012). Living labs are seen as open innovation networks or platforms with strong user involvement, emphasizing the role of intermediaries coordinating the network partners involved in innovation (e.g. Katzy et al., 2012). In contrast, Living labs are also defined more narrowly as a specific network organization connected to a real-life environment (physical place) with a strong involvement of user-groups in co-creation with researchers and producers. The two conceptualizations do not exclude each other as the second one can be part of the first one. In this paper, we use the *narrow* definition, because it allows a greater focus in analysis of the actual processes, outcomes and critical factors in boundary-spanning activity.

There are differences within the narrow concept, depending on the aim (domain) of the Living lab, like healthcare, traffic, energy-saving, etc. and on the mix of actors involved (Leminen et al., 2012; Nystrøm et al., 2014). A related distinction is that between people-oriented Living labs, in which the innovations serve individual people, like patients, the elderly, commuters, etc. and institution-oriented Living labs, like hospitals, shopping centers, sporting facilities, etc. Specifically the last distinction leads to diverse complexity in managing the Living lab, with organization-oriented Living labs being connected to a larger number of user-groups and other actors, each with potentially different interests (Arnkill et al., 2000; De Bruijn et al., 2010; Almirall et al., 2012).

Co-creation

We now focus in on co-creation by user-groups that distinguishes Living labs from other initiatives. In general, user involvement may range from leading co-creators at one extreme to passive subjects at the other extreme (see Figure 1) (Arnkil et al., 2010; Almirall et al., 2012). However, only those types of involvement are included in this paper that qualify as (close to) co-creation (Nystrøm, 2014). If user involvement is basically less intensive and interactive, ‘adjacent’ concepts apply, like ‘usability testing’ and ‘design thinking’ which qualify as user-centered but not user-driven.

In practice, co-creation teaches other participants of the Living lab about values and preferences of users, system/product characteristics considered by them as unwanted or unnecessary, specifically those causing annoyance in use, and about ideas on product improvement in current and future situations (scenario’s) etc. Accordingly, co-creation includes various key learning activities between researchers, users and producers requiring high levels of trust and commitment between all of them (Zaheer et al., 1998; Pralahad and Ramaswamy, 2004).

A related development including co-creation is that of ‘Smart Cities’, which can be conceptualized as cities in which digital technologies translate into better – more interactive and responsive – city administration and public services, better use of resources and a less negative impact on the environment (Batty et al., 2012; EC, 2012; Trencher et al., 2014). All this is enabled by a technical information infrastructure, including real-time feedback sensors, wireless networks and software to manage the data involved. The idea has emerged that Smart Cities can be used not only for monitoring and steering, but also as a real-life environment for interactive experimentation and co-creation of new ideas and urban technologies, which is where the narrow concept of Living labs makes its appearance.

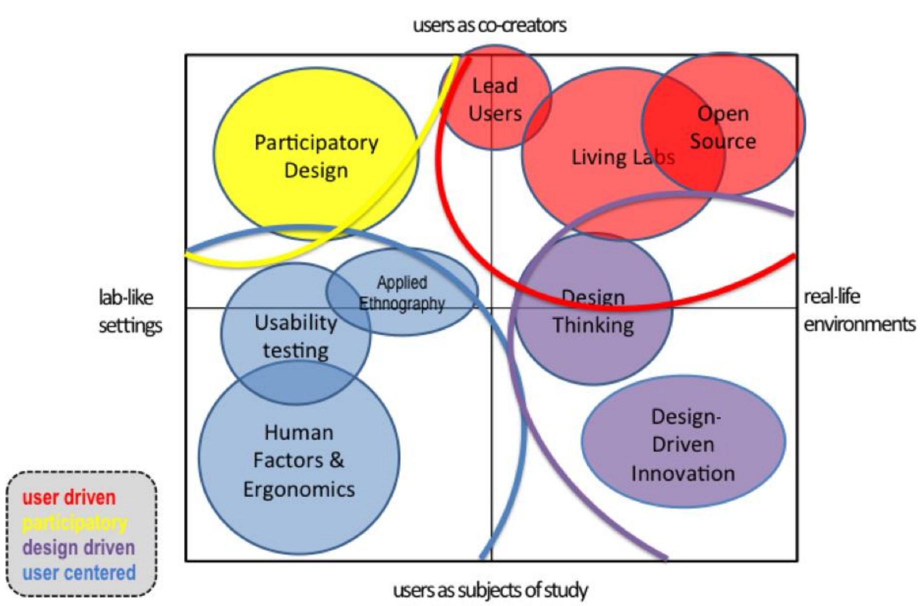

Figure 1 User involvement according to two dimensions: research labs versus real-life environment and passive versus active involvement (Source: Almirall et al., 2012).

Preliminary components of a framework

The study draws on a scan of the literature, workshop experience with experts and interviews with actors, all enabling to develop building blocks of a preliminary framework of critical factors, and on four case studies' evaluation. The scan of the literature on Living labs covers approximately a 10 year period from 2005 to 2014. Further, in selecting the case studies, we followed the method of 'theoretical sampling', meaning selection on contrasting 'theoretical positions' (Eisenhardt and Graebner, 2007), in this study derived from difference in actor complexity and difference between people- and organization-orientated Living labs.

In literature, five critical factors of boundary-spanning activities by Living labs have been identified (Almirall et al., 2012; Leminen and Westerlund, 2012, Leminen, 2013; Ståhlbrost, 2012). First, the involvement of user-groups is most often mentioned as critical, particularly the need for an adequate selection of them enabling an intensive interaction. This requires a sufficient match between R&D issues and commitment by users, however, the requirement of sufficient commitment touches upon an ambiguity. On the one hand, it is important to include sufficiently motivated users, but on the other hand, including people who are less motivated seems also necessary to understand the reasons behind their lack of motivation. Further, selecting the right users also means selecting persons who are able to contribute actively to the learning and design process on the basis of sufficient skills, for instance, in terms of dealing with information tools and communicating their personal needs, experiences and expectations. At the same time, it is also critical that there is a sufficient integration and absorption of the knowledge gained from users in the multidisciplinary development and design processes (De Moor et al., 2010).

Secondly and by definition, the real-life environment is crucial. In existing literature, the real-life environment is rarely included as a factor that deserves some key attention. This is remarkable, because the physical dimension introduces questions on, for example, access and openness of a room or building in relation to what is public and what is private, and on the legal aspects of implementing (ICT) infrastructures in those places. Such issues do not apply if the Living lab works (combines) with virtual reality and virtualization of changes in the physical environment and user objects aimed at enhancing imagination and creativity.

Thirdly, the composition of actors in the core network tends to be as important as the involvement of users. There is a need to avoid too many actors, one of them dominating others, and a strong interdependency between them. If highly diverse actors are involved, particularly when they deal with contrasting interests, there is a serious chance for conflict in decision-making, whereas a strong dominance of one large actor may deter smaller parties from participating (Guldemond and Van Geenhuizen, 2012). In addition, if there is a strong dependency between two or three actors, withdrawal by one of them in times of conflict may lead to withdrawal of the others, endangering the survival of the Living lab (and constituent projects), as insights from complex technical projects illustrate (Flyvbjerg et al., 2005; De Bruijn et al., 2010). Needless to say, the composition of participants and quality of the management are crucial, specifically in terms of avoiding imbalances in power and in creating the 'air' of equality and flexibility between actors, while managing actors' expectations.

A fourth crucial factor is the way in which the innovation process is structured. Living labs constitute the environment in which practical innovation proposals and projects are being developed, scanned and eventually forwarded with the aim of attracting financial investment. These activities require a clear model, like a funnel, as well as a transparent decision-making structure, including various go/no-go decisions, in order to produce sufficiently attractive business propositions (Guldemond and Van Geenhuizen, 2012). Finally, there is a set of values and requirements mentioned in the literature that need to be sufficiently addressed, preferably prior to start (Dutilleul et al., 2010). These include legal issues concerning liability and intellectual ownership, but also particular human values, concerning trust and privacy, and being familiar with ICT, the last particularly in those cases where the mental/cognitive distance between user-groups and ICT is large, due to culture and age.

Case Studies of Living Labs

Introduction

Despite the many inventions in medical technology and healthcare, a lot of R&D is still needed to bring these inventions to market and customize them to user needs (e.g. Nambisan and Nambisan, 2009; Shah et al., 2009), an area in which Living labs tend to be considerably helpful. There are two reasons why attention to the healthcare sector is justified. First, there is a need in our society to keep healthcare affordable, given the increased share of elderly in the population and the increase in chronic diseases, and at the same, there is a need to make healthcare services more effective (EC, 2012). Secondly, the medical sector is faced with strong actor complexity, including different types of users and other stakeholders, like patients, surgeons, care professionals and hospitals, as well as insurance companies, regulatory agents, universities, large and small pharmaceutical and medical technology firms, public authorities, NGOs, etc., placing high demands on the composition and management of the networks involved. However, there are differences between Living labs in this complexity and that is one of the selection criteria for the case studies. In all case studies, the main data source is an ex-post evaluation by the organization involved and by external evaluators, except for Case study 4, which is in a preliminary evaluation stage (Kop, 2011; Ruff and Jakobson, 2012; Amsterdam Region Care & ICT, 2013; Van der Vloed and Sadowski, 2013; Kehayia et al., 2014). The results are summarized in Table 1 and Table 2.

The first two case studies are people-oriented, both in ambient-assisted living for elderly of which one is relatively simple and the other more complex, while the last two are institution-oriented of which one is relatively simple in dealing with hospital renovation and medical technology and the other more complex in dealing with refurbishment of a shopping mall and increasing accessibility to disabled people. Accordingly, Case study 1 represents small projects with the aim of extending the time elderly can live independently at home by the use of smart homes (home automation) and e-health tools, including home fitness. Case study 2 represents more comprehensive and complex projects in elderly care. It introduces a larger range of ICT solutions and different user roles (inputs) aside from co-creation, while the university is stronger involved. Case study 3 represents various focused projects exploring simulation potentials in hospital design/renovation and in development of e-health products/services. And finally, Case study 4 represents comprehensive and complex projects located in shopping mall or public transport stations with the aim of improving social inclusion of disabled people by creating adequate adjustments in refurbishing the building and in wheelchair navigation.

Living labs for ambient assisted living

Case study 1, in the region of Eindhoven (the Netherlands), targeted a rather specific user group, namely elderly people of Turkish origin. In terms of technology, the Living lab was relatively simple, without brand new innovations. It started in 2010, with the aim of providing accessible ICT tools for three purposes: 1) home care (low threshold Skype interface with care-providers), 2) home fitness training and health improvement, and 3) home safety (sneak-thief detection and emergency button), as well as adapting the technology solutions to the specific user group. The complexity was social in nature, given the cultural barriers with the user group of Turkish elderly (Kop, 2011). The Living lab had no direct relation with technology inventions at university and, as such, played no role in bridging gaps between the partners. The local technical university performed an ex-post external evaluation of the project, but did this ‘at a distance’ (Van der Vloed and Sadowski, 2013).

Finding ways to involve the user group turned out to be of key importance, particularly given the cultural background of the users and the ‘distance’ between modern ICT and their culture and living. Therefore, a solid preparation was undertaken by learning about user needs prior to the project design, and by employing coaches from the Turkish community to create trust between users and researchers (in some cases grand-children acted as coaches). Different from what was found in literature, a particular structuring of the innovation process was not necessary, because no large numbers of inventions were expected to emerge. Overall, commercial aspects were given minor attention.

Regarding achievements, the target group became more involved in home fitness and improved their health condition by accepting some ICT-based health and safety support, and they suggested certain additional safety protection solutions in their homes (bathrooms). With regard to boundary spanning, a set of appropriate partners worked adequately together, however, the university has remained somewhat off-side by merely acting ex-post as an external evaluator.

Case study 2 (Living Lab Amsterdam) is more extended in ICT solutions, particularly in monitor daily life behavior. It is also clearly embedded in university and other higher educational institutes’ research, with technology solutions and psychology support from the academic hospital and medical faculty, and with project management, including monitoring. The stronger boundary spanning with academia in this case study can be seen as being enhanced by a major player in the region and that is the Amsterdam Economic Board, in which the Triple/Quadruple Helix is clearly represented. In user-involvement a mix of more and less active methods is used, including interviews on testing ICT applications, design of scenarios on future use, acting in focus groups and co-creation of specific applications, all with the aim of obtaining a rich feedback and input from users.

The Living lab started in 2011 at various locations of independently living elderly people in the Amsterdam area. The monitoring - using sensor technology - in this project served two goals: to measure activities of daily life (ADL) indicating the level of independence and need for support, and to combine with other services such as an alarm system, a mood button, etc. Trust between the elderly and researchers and care professionals was increased by using already established personal relationships with the elderly, and by showing them a working version of the new solution before the project started. With regard to legal issues and ethics/values connected to the monitoring system, privacy turned out to be a serious issue, aside from the desire for self-determination and temporary switching off of the system. In addition, the timing of the installation of the sensors in the homes turned out to be an issue, i.e. prior to or after the invitation to participate in the Living lab, which was essential in enabling a proper choice by the elderly for participation.

The main achievements of this Living lab can be seen as an increased acceptance of ICT tools for living and home care, and additionally a much better insight into the wishes and values of elderly people in these respects. However, no substantial commercial progress was made in terms of a broad implementation of the ICT applications, but the aims were also rather weak. In terms of boundary–spanning, therefore, we may conclude that the necessary actors have been involved in collaborative learning, with the exception of the business world that has remained somewhat off-side.

Table 1. Local Living labs: elderly housing and ambient assisted living

	Case study 1	**Case study 2**
Name	Doornakkers: living area Eindhoven (Netherlands)	Living Lab Amsterdam
Working years	2010-2011	2011-2013
Application domain	ICT (domotics) and healthcare	ICT (domotics) and health care
Aim and means	Affordable healthcare and illness prevention, through increased use of ICT tools for home care, fitness training and home safety	Affordable healthcare and illness prevention, by increasing acceptance of a broad set of ICT tools for housing and home care
User group and roles	Elderly of Turkish origin; passive role but could switch to active	Elderly (different groups); combination of roles (passive and active)
Complexity (stakeholders/task)	Low complexity	Somewhat larger complexity
Physical setting	Living quarter: homes	Various independent houses of seniors
Core of network (other than users)	Care provider; Eindhoven city; Brainport Innovation; security services company, social housing provider	Amsterdam Region Care & ICT; Care society; Amsterdam city and Province; University of Applied Science, University of Amsterdam, Free University; Waag Society (creativity input)
University involvement	No direct involvement in technology solutions, but acting as external evaluator	Input of domain technology and of management knowledge to analyze the process (monitoring)
Structured innovation process	Open structure, allowing new applications entering the project	Open structure, allowing new applications entering the project; weak commercial aims set
Legal, ethical and cultural values	Cultural values of users respected	Privacy protection and desire for self-determination of users
Approach to ICT	Recognition of culture gap between ‘soft’ care and ICT, but well- managed (ease of use)	Recognition of culture gap between ‘soft’ care and ICT, but well-managed (ease of use); sensor systems need to be safe (privacy) and inspire trust

Additional critical factor(s)	1) Preparation: study of user needs *prior* to project design 2) Specific coaches to develop *trust*	1) Mixed methods of user involvement 2) Multi-disciplinary approach 3) Building *trust* prior to project start
Achievements innovation	Increased use of ICT with better physical health condition of users	Increased acceptance of ICT solutions, and improved understanding of user behavior
Achievements Triple /Quadruple Helix boundary-spanning	Indirect evidence of positive results, but university remained off-side (acted as external evaluator)	Integration of a set of important actors, but the business world has remained somewhat off-side due to weak aims

Source: Kop (2011); Amsterdam Region Care & ICT (2013); Vloed and Sadowski (2013).

Institution-related Living labs

Case study 3, Health Innovation Lab (HIL), is part of a larger initiative in the Copenhagen area, in Denmark, called the Healthcare Innovation Centre. HIL was small in scale and had a unique aim, namely to design a *methodology* in healthcare innovation (hospital design/renovation and e-health solutions) that combines user-driven innovation and simulation. From 2010 to 2012, it was in the stage of demonstration projects (simulation labs), and various projects were accomplished in 2012, for example, an 'Outpatient Clinic of the Future'. The aim of each demonstration project involving the university hospital, was to identify and realize solutions that are scalable and transferable to similar departments in other hospitals in the region. Unlike the previous case studies, hospitals were involved as a user group, based on their demand for inventions in new construction (or renovation) of hospital buildings and room design, like operating theatres and patient waiting rooms. Accordingly, users from relevant backgrounds were involved in the core network and, in this context, a critical factor turned out to find a good match between user capabilities and skills regarding the handling of simulation tools. ICT did play an advanced role in these tools as well as in the domain of e-health involved, including remote treatment and monitoring, but also data retrieval from readings at home and remote dialogue.

With regard to the innovation process, HIL used the funnel model, but go/no-go decisions were less relevant in terms of commercialization, because of the limited aim of finding viable innovation tools for hospitals in the region. Regarding practical requirements involving HIL's performance, ethical and legal issues seemed less relevant. However, in terms of management a tight model was particularly important, allowing for openness in the initial stages but closing the innovation process later on. Unlike the two previous case studies, HIL organized training and team building to encourage all parties to interact proactively and to accelerate the processes. So far, commercial success is limited, as HIL to a large extent is publicly financed (national and regional authorities) and designed solutions for a limited application.

HIL has been the subject of evaluation as a set of demonstration projects (Ruff and Jacobsen, 2012). Some of the best-practice factors in management were found to be a multidisciplinary input, willingness to take risk and passionate decision-making by managers, and open dialogue and communication. Accordingly, much emphasis has been placed on 'human values' among the network partners. Further, aside from increased insights into innovation management, the main results are the sets of rules to which particular innovations (hospital design, e-health solutions) need to respond. In terms of boundary-spanning in a narrow sense, this living lab – like the previous one- has brought an important set of Triple/Quadruple Helix partners together, but the business world has remained off-side.

Case study 4 is situated in a shopping mall in Montreal (Canada) and started in 2011 (Kehaya et al., 2014). With enhancing social inclusion of disabled people as background, the aim was to design better solutions to problems in wheel-chair navigation and way-finding technology, in combination with novel reconstruction of the shopping mall. The Living lab was organized in such a way that the two main user-groups, disabled persons and rehabilitation services providers, could adopt different roles like co-creation, testing, being part of focus groups, etc. Unlike all previous case studies, commercial partners played a strong role because they were given the responsibility to co-create the solutions and bring them to the pilot stage. However, structuring the innovation process, using a selection model for viable solutions, turned out not to be an issue of importance.

With regard to practical requirements/values, enhancing a strong commitment and partnership between the core actors was considered important, aside from a multi-disciplinary and multi-sector approach. This Living lab is also different from previous ones in that progress in solutions was advanced by a broad setting of activities in the 'spirit' of participatory action research, community of practice (CoP) and international research and business relations.

Table 2. Local Living Labs: Hospital setting and shopping mall

	Case study 3	**Case study 4**
Name	Healthcare Innovation Lab, (part of Health Care Innovation Centre), Copenhagen, DK	Rehabilitation Living Lab (Montreal downtown shopping mall Alexis Nihon), Montreal Canada
Working years	Feb. 2010-2012 (demonstration projects)	2011 - ..
Application domain	Methodologies to design new medical services (e-health) and hospital rehabilitation	New technical solutions (rehabilitation) designed to remove social and physical barriers in shopping malls
Aim and means	Design of methodologies of user-driven innovation in identification of innovation potentials in hospitals and telemedicine (using simulation*)	Develop technology and intervention (e.g. rehabilitation and reconstruction in shopping malls) to increase social inclusion of disabled people
User group and roles	Clinicians and hospital (University Hospital Herlev), and *selected* patients: highly active and interactive (simulation)	Disabled people and rehabilitation service providers: active role
Complexity (stakeholder/task)	Medium complexity	Large complexity
Physical setting	Hospital (diverse rooms) and homes (telemedicine); additional virtualization	A 'renovation' ready shopping mall

Core of network (other than users)	Regional hospitals; Capital Region of Denmark and Danish Business Authority (both financial investors)**	Shopping mall organization and merchants, various universities (including abroad), community based associations, companies
University involvement	Input of domain knowledge and of management knowledge (through university hospital)	Input of domain knowledge and of management knowledge to analyze the process (monitoring)
Structured innovation process	Open process followed by closing in next steps (funnel)	Not an issue so far
Legal, ethical and cultural values	Passion and somewhat risk-taking among management in decision-making	Deep commitment of actors to success of the project
Approach to ICT	Delicate approach, with ICT as part of main design methodology (simulation); instruction of users needed	Part of the solutions (e.g. smart wheelchairs and adapted GPS system); no specific approach needed
Additional critical factors	-Tight management of openness and closing of the innovation process -Need for *trust* creation between actors -Multi-disciplinary input	-Multi-disciplinary and multi-sector input -Excellent rehabilitation research input -Linked with a community of practice
Achievements innovation	Sets of rules to which innovations need to respond have been achieved; also, insights in management of these types of innovation (tools)	Innovation in wheel-chair and navigation technology and in refurbishing and path-signing in shopping malls; also improved insights into multi-disciplinary and multi-sector aspects of innovation
Achievements Triple/Quadruple Helix boundary-spanning	Integration of a set of important actors, with the business world somewhat off-side due to weak aims	Integration of all important actors

*Simulation of real-life and imaginary situations to generate new ideas and inventions.
** Regional Innovation program, partially financed by Ministry of Economic Affairs.
Sources: www.centerforsundhedsinnovation.dk; Ruff and Jacobsen (2012). Kehayia et al. (2014).

The results of the Living lab can be summarized as improvement in wheel-chair and navigation technology and in refurbishing technology of shopping malls, and, additionally, greater insight into the multidisciplinary and multi-sector aspects as analyzed by the involved universities. In terms of boundary-spanning, this Living lab is the only one of the four in this study in which all Triple/Quadruple Helix actors have been involved and integrated.

Summary of critical factors

The factors as identified in literature, and further explored in the case studies, are shown in Table 3. Two factors or parts of them derived from literature appear less important in the case studies, firstly, requirements of the real-life environment, and secondly, having a properly structured innovation process. The last one appears to be due to the (very) limited involvement of the business sector in the case studies, except for Case study 4.

Table 3. Critical factors in Living labs' boundary-spanning

Factors	*Details*
1.Involvement of user-groups	-Adequate user group selection and involvement: ✓ motivation among users ✓ capabilities and skills to perform their roles ✓ early attention for critical user-values ✓ absorption of user input in running design and development processes -Timely preparation to dealing with 'vulnerable' users (prior to project start)
2.Real-life environment	-Per definition a requirement -Important legal issues concerning access to places and privacy
3.Actor network and management	-Involvement of all relevant actors in a 'balanced' fashion, avoiding: ✓ a too large number ✓ a clear dominant one ✓ strong interdependency between dominant ones -Openness and neutrality -If a complex situation: a multi-sector and multi-disciplinary approach
4.Structured innovation	-If basically commercially oriented: a 'funnel' or other selection mechanism of promising projects with transparent go/no-go decisions
5.Practical requirements and values	-Strong involvement of ICT for monitoring of user responses and part of co-creation/design work; however, avoid strong emphasis if culture gap -Give sufficient attention to: ✓ ethical/legal issues, like legal liability and IP issues ✓ user values, like privacy, cultural identity and self-determination/independency ✓ values in management: trust-building, commitment, risk-taking -Make better use of universities, as an 'objective' evaluator and an actor in monitoring and mutual learning

What the analysis additionally provides are important *details* on the main differences between people-orientated and institution-orientated Living labs. For example, the case studies involving elderly people indicate the importance of a timely learning about and responding to user-needs, including specific ethical values like self-determination and the need for trustworthy relationships. By contrast, the hospital and shopping mall Living labs indicate the importance of having strong commitment between core-actors and a passionate and somewhat risk-taking behavior in management, as well as adoption of a thorough multi-disciplinary and multi-domain approach. In addition, the case studies also reveal different roles of the university, ranging from merely an 'outsider' in ex-post evaluation to a fully integrated partner providing technology as well as management/monitoring and negotiation input, suggesting the importance of multiple roles (Kuhlmann, 2003).

Conclusion

This paper contributes to existing literature as one of the first attempts to analyse Living labs' boundary-spanning activities, by using a narrow conceptualization while distinguishing between people-oriented and institution-oriented Living labs. Five critical factors were derived from literature and explored in more detail using case study results. The main critical factors turned out to be 1) an adequate user-group selection and involvement, specifically a rich interaction and absorption, 2) a balanced involvement of all relevant actors, and 3) a sufficient (early) attention to values, both of users and management. Management of people-oriented Living labs requires a strong attention to user values, while management of institution-oriented Living labs requires strong attention to commitment and passion between diverse actors (multi-disciplinary and multi-sector).

With regard to universities, a wide range of involvement can be observed, from off-side in a position of external evaluator to a strong involvement including highly diverse inputs in both the domain (technology) and management and monitoring of the Living lab. Similarly, the business world tends to be largely off-side in less commercially oriented Living labs, while it can also act with fully involved business partners. In this respect, the conclusion can be drawn that there is quite some differentiation in boundary-spanning activity by Living labs, both in bringing the required partners together and in reaching the ultimate aim of collaborative learning and co-creation by these partners.

Like most studies, this study has some shortcomings, one of which is the limited area in Europe from which three of the four case studies were drawn, namely northwest Europe, which may makes it harder to generalize the results, due to specific cultural traits and values (Hofstede and Hofstede, 2005). A second potential shortcoming is the limited size of the sample itself, namely, only four case studies. Though consciously selected, 'theoretical generalization' may be limited. In addition, the focus has been on the healthcare sector which is relatively complex in terms of actor involvement (Guldemond and Van Geenhuizen, 2012). Next step in the research, therefore, could include data collection to establish a much larger sample that is representative in a statistical sense. A decision needs to be made as to which countries to include - within and outside the European Union - which sectors to cover, namely to enable to test the framework outside the healthcare sector like in sustainable energy and safety, and which types of Living labs to focus on, like people-oriented and organization-oriented ones or a mix.

In some *developing* countries, Triple Helix development is facing institutional barriers due to fragmentation and rigidity, in a situation in which universities are mainly involved in education and large companies used to source new knowledge from abroad, instead of local. There are nevertheless huge opportunities here, as already illustrated by some countries in Latin America and East Asia (Saad and Zawdie, 2011). Getting universities more entrepreneurial with small spinoff firms fostered in incubators and with experiments with small-scale Living labs, could be some of the first steps to create a fertile seedbed for Triple Helix development and growth of the regional knowledge economy.

References

Almirall, E. and Wareham, J. (2008). Living Labs and Open Innovation: Roles and Applicability. The Electronical Journal for Virtual Organizations and Networks 10, 21-46.

Almirall, E. and Wareham, J. (2011) Living Labs: Arbiters of Mid and Ground-Level Innovation, Technology Analysis and Strategic Management, 23(1), 87-102.

Almirall, E., Lee, M., and Wareham, J. (2012) Mapping Living Labs in the Landscape of Innovation Methodologies. Technology Innovation Management Review, September 2012, 12-18.

Amsterdam Region Care & ICT (2013) Innovating in care in collaboration with the end-user. Amsterdam.

Arnkil, R., Järvensivu, A., Koski, P. and Piirainen, T. (2010) Exploring Quadruple Helix. Outlining user-oriented innovation models. University of Tampere, Institute of Social Research.

Batty, M., Axhausen, K., Gianotti, F. et al. (2012) Smart cities of the future, The European Physical Journal – Special Topics, 214, 481-518.

Bergvall-Kåreborn, B. and A. Ståhlbröst (2009). Living lab – an open and citizen-centric approach for innovation. Int. Journal of Innovation and Regional Development 1(4), 356–370.

Bjerregaard, T. (2010) Industry and academia in convergence. Micro-institutional dimensions of R&D collaboration, Technovation 30 (2), 100-108.

Bretznitz, S.M. and Feldman, M.P. (2012) The Engaged University. Journal of Technology Transfer, 37 (2), 139-157.

Bruneel, J., d'Este, P., Salter, A. (2010) Investigating the factors that diminish the barriers to university, industry collaboration, Research Policy, 39, 858-868.

Bruijn, H. de, Heuvelhof, E. and R. in 't Veld (2010) Process Management: Why Project Management Fails in Complex Decision-Making Processes, 2nd edition. Heidelberg/Berlin: Springer.

Chesbrough, H. (2003) Open Innovation. The New Imperative for Creating and Profiting from Technology. Cambridge: Harvard Business School.

Chesbrough, H., Vanhaverbeke, W. and West, J. (2006) Open Innovation: Researching a New Paradigm. New York: Oxford University Press.

DFKI (German Research Center for Artificial Intelligence) (2014) Living Labs, www.dfki.de, accessed January 15, 2015).

Dubé, P., Sarrailh, J. and I. Kostecki (2013) Introduction to living labs. Montréal inVibo (in French), Quebec, Umvelt.

Dutilleul, B., F. A. J. Birrer and W. Mensink, (2010). Unpacking European Living Labs: Analysing Innovation's Social Dimension. Central European Journal of Public Policy, 4, 60-85.

EC (European Commission) (2009) Living Labs for user-driven open innovation. Luxembourg.

EC (European Commission) (2011) Horizon 2020. The Framework Programme for Research and Innovation. Communication from the Commission. Brussels.

EC (European Commission) (2012) eHealth Action Plan 2012-2020 - Innovative healthcare for the 21st century. Brussels.

EC (European Commission) (2012) Digital Agenda for Europe. A Europe 2020 Initiative. Brussels. http://ec.europe.eu/digital-agenda/en/about-smart-cities (accessed June 15 2014).

Eisenhardt, K. and Graebner, M. (2007) Theory-building from cases: opportunities and challenges, *Academy of Management Journal*, 50 (1), 25-32.

Enkel, E., Gassmann, O., and Chesbrough, H.W. (2009) Open R&D and open innovation: Exploring the phenomenon. R & D Management, 39 (4), 311–316

ENoll (European Network of Living Labs) (2014) About us. www.openlivinglabs.eu/aboutus (accessed April 15 2014).

Eriksson, M., Niitamo, V.P. and Kulkki, S. (2005) State-of-the art in utilizing Living Labs to user-centric ICT innovation – a European approach. Lulea University of Technology.

D'Este, P. and Patel, P. (2007) University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? Research Policy, 36, 1295-1313.

Etzkowitz, H. and Leydesdorff, L. (1998) The endless transition: a "triple helix" of university-industry-government relations, Minerva, 36, 203-208.

Etzkowitz, H. (2008) The Triple Helix: University-Industry-Government Innovation in Action. London: Routledge.

Fahy, C., M. Ponce de Leon, A. Ståhlbröst and Schaffers, H. (eds) (2007) Services of living labs and their networks. Expanding the Knowledge Economy. Amsterdam, IOS Press.

Flyvbjerg, B., M. K. S. Holm and S.L. Buhl (2005). How (in) accurate are demand forecasts in public works projects? The case of transportation. Journal of the American Planning Association 71(2), 131-146.

Følstad, A. (2008). Living Labs for Innovation and Development of Communication Technology: A Literature Review. The Electronic Journal for Virtual Organizations and Networks 10, 99-131.

Füzi, A. (2013) Quadruple Helix and its types of user-driven innovation. 13the Triple Helix Conference, London.

Geenhuizen, M. van (2013) From Ivory Tower to Living Lab. Accelerating the Use of University Knowledge, Environment & Planning C (Government and Policy) 31 (6), 1115-1132.

Geenhuizen, M. van (2014) Critical Factors in Health Innovation in Cities: From Ivory Tower to Living Lab. Int. Journal of Global Environmental Issues, 13 (2-4), 258-280.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994) The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies. London, Sage.

Goddard, J. and Vallance, P. (2013) The university and the city, Routledge.

Guldemond, N. and Geenhuizen, M. van (2012) Critical Factors in 'Livings Labs' for New Health Concepts and Medical Technology, CESUN Int. Engineering Systems Symposium, Delft, NL, 18-20 June 2012 (www.cesun2012.tudelft.nl).

Harvey, S., Peterson, R.S. and Anand, N. (2014) The Process of Team Boundary Spanning in Multi-Organizational Contexts, Small Group Research, 45 (5), 506-538.

HICD (2013) Healthcare Innovation Centre Denmark, http://www.regionh.dk/HealthcareInnovationCentre/Menu/. (accessed September 13 2013)

Hippel, E. von (1986) Lead users: a source of novel product concepts. Management Science, 32, 791–805.

Hippel, E. von (2005) Democratizing Innovation. Cambridge (MA): MIT Press.

Hofstede, G. and Hofstede, G.J. (2005) Culture and Organizations: Software of the Mind. (revised.2nd edition) New York: McGraw Hill.

Howells, J. (2006) Intermediation and the role of intermediaries in innovation. Research Policy 35(5): 715-728

Jehn, K.A and Mannix, E.A. (2001) The dynamic nature of conflict: a longitudinal study of intra-group conflict and group performance. Academy of Management Journal, 44, 238-251.

Katzy, B.R., Pawar, K.S. and K-D Thoben (2012) Editorial: A Living Lab Research Agenda, Int. J. Product Development, 17(1/2), 1-7.

Kehayia, E., Swaine, B. et al. (2014) Creating a rehabilitation living lab to optimize participation and inclusion for persons with physical disabilities, ALTER, European Journal of Disability Research, 8, 151-157.

König, A. (2013) Regenerative Sustainable Development of Universities and Cities, Cheltenham: Edward Elgar.

Kop, W. (2011). User guide: Smart Care and participation by specific user groups. Eindhoven, P. Advisors.

Kuhlmann, S. (2003) Evaluation of research and innovation policies: a discussion of trends with examples from Germany. Int. Journal of Technology Management, 26 (2/3/4), 131-149.

Leminen, S. and Westerlund, M. (2012) Towards Innovation in Living Labs Network. International Journal of Product Development, 17 (1/2), 43-59.

Leminen, S. (2013) Coordination and Participation in Living Lab Networks. Technology Innovation Management Review, November 2013, 1-12.

Leminen, S. Westerlund, M. and Nystrøm, A-G (2014) On Becoming Creative Consumers – User Roles in Living Labs Networks. International Journal of Technology Marketing, 9 (1), 33-52.

Leydesdorff, L. and Meyer, M. (2007) The scientometrics of a Triple Helix of university, industry, government relations (Introduction to the topical issue), Scientometrics 70 (2), 207-222.

Marrone, J.A., Tesluk, P.E., and Carson, J.B. (2007) A Multilevel Investigation of Antecedents and Consequences of Team Members Boundary Spanning Behavior, Academy of Management Journal, 50 (6), 1423-1439.

Meyer, M. and Kearnes, M. (2013) Introduction to special section: Intermediaries between science, policy and market. Science and Public Policy, 40, 423-429.

Moor, K. de, Berte, K., De Marez, L. and Joseph, W. (2010) User-driven innovation? Challenges of user-involvement in future technology analysis. Science and Public Policy, 37 (1), 51-61.

Mørk, B.E., Hoholm, T., Maaninen-Olsson, E, and Aanestad, M. (2012) Changing practice through boundary-organizing: a case from medical R&D. Human Relations, 65 (2): 263-288.

Nambisan, P. and S. Nambisan (2009). Models of consumer value co-creation in health care. Health Care Management Review 34(4), 344-354.

Nembhard (2012) All technology, all learn, all improve? Health Care Management Review 37 (2), 154-164.

Nooteboom, B. (2009) A Cognitive Theory of the Firm. Learning, Governance and Dynamic Capabilities. Cheltenham: Edward Elgar.

Nystrøm, A-G, Leminen, S., Westerlund, M. and Kortelainen, M. (2014) Actor Roles and Role Patterns Influencing Innovation in Living Labs. Industrial Marketing Management, 43(3), 483-495.

Philips, F. (2014) Triple Helix and the Circle of Innovation, Journal of Contemporary Eastern Asia, 13 (1), 57-68.

Prahalad, C.K. and Ramaswamy, V. (2004) Co-creation experiences: The next practice in value creation. Journal of Interactive Marketing, 18 (3), 6-14.

Ranga, M. and Etzkowitz, H. (2013) Triple Helix systems: an analytical framework for innovation policy and practice in the Knowledge Society. Industry & Higher Education, 27 (3), 237-262.

Ruff, S.A. and Jacobsen, E. (2012) Healthcare Innovation Lab. Copenhagen: Healthcare Innovation Centre.

Saad, M. and Zawdie, G. (eds) (2011) Theory and Practice of the Triple Helix System in Developing Countries. Issues and Challenges. New York: Routledge.

Sauer, S. (2013) User Innovativeness in Living Laboratories. Enschede: Center for Telematics and Information Technology (CTIT) (PhD thesis).

Schot, J. and Geels, F.W. (2008) Strategic niche management and sustainability innovation journeys: theory, findings, research agenda, and policy, Technology Analysis & Strategic Management, 20 (5), 537-554.

Shah, S. G. S., I. Robinson and S. AIShawi (2009). Developing medical device technologies from users' perspectives: A theoretical framework for involving users in the development process. International Journal of Technology Assessment in Health Care, 25(4), 514-521.

Ståhlbröst, A. (2008). Forming Future IT - The Living Lab Way of User Involvement. Dept. of Business Administration and Social Sciences. Luleå University of Technology.

Ståhlbröst, A. (2012) A set of key principles to assess the impact of Living labs. International Journal of Product Development, 17 (1/2), 60-75.

Tidd, J., and Bessant, J. (2009) Managing Innovations. Integrating Technological, Market and Organizational Change, 4th edition, John Wiley.

Todeva E (2013) Governance of innovation and intermediation in Triple Helix interactions. Industry & Higher Education 27(4), 263-278.

Trencher, G.P., Yarime, M. and Kharrazi, A. (2013) Co-creating sustainability: cross-sector university collaborations for driving sustainable urban transformations. Journal of Cleaner Production, 50, 40-55.

Vloed, G.A., van der, and Sadowkski, B. (2013) Final Report TU/e for Living lab Eindhoven. Eindhoven: TU/e.

Williams, P. (2002) The competent boundary spanner. Public Administration, 80 (1), 103-124.

Zaheer, A., McEvily, B. and Perrone, V. (1998) Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. Organization Science, 9, 141-159.