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Living Labs as Quasi-experiments: Results from the Flemish LeYLab

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Abstract: Living Labs are seen as open innovation systems adopting a user-centered approach (Schuurman et al., 2012), but academic research into the methodological elements is still lacking, resulting in a diversity of definitions, approaches and characteristics (Følstad, 2008; Almirall & Wareham, 2011; Leminen & Westerlund, 2012). Within this paper, based upon a literature review, we propose a conceptual model of a Living Lab constellation, facilitated by a given material and immaterial infrastructure, which facilitates

Living Lab-cases that follow a quasi-experimental design. Through an in-depth case study analysis of the LeYLab Living Lab constellation and six separate cases running in the Living Lab, we assess the applicability of our model and abstract some general lessons learned. Our study demonstrates the potential of infrastructure-driven Living Labs, but also that the allignment of external utilizers with this infrastructure can be problematic.

Keywords: Living Labs, Open Innovation, Quasi-experiments, User-centric Innovation, Domestication, Innovation Management.

1 Introduction

In the transition towards a knowledge economy, innovation is becoming more and more important for companies to remain competitive in an increasingly global economy. However, high flop-rates still illustrate the need for an adequate management of innovation, which includes selecting the right tools and methods in order to structure and optimize innovation processes (Brem and Viardot, 2013). For companies, it is necessary to attain an optimal level of ambidexterity, or the capability to explore external knowledge and valorize or exploit this knowledge for internal benefit (Andriopoulos and Lewis, 2009). Traditionally, Europe scored high in terms of research (exploration), but underperformed in terms of market success (exploitation), a phenomenon referred to as the 'European Paradox' (Almirall and Wareham, 2011). In order to overcome this paradox, several initiatives were started on the European policy level, amongst them also the so-called Living Lab approach starting in 2006 (Dutilleul et al., 2011).

Living Labs can be seen as a rather new research area with only a limited amount of supporting theories for understanding this concept (Ståhlbröst & Bergvall-Kåreborn, 2008). The absence of supporting theories, or rather the lack of agreement regarding the supporting theories (Eriksson et al., 2005; Schaffers & Kulkki, 2007) has induced on the one hand a proliferation of papers and articles on Living Labs and on the other hand a wide variety of approaches and projects carried out under the flag of the Living Lab-concept (Shamsi, 2008). In short, on a theoretical as well as on a practical level, a further narrowing and specifying of the Living Lab-concept remains a task in progress. In this paper, we will add to the current literature by focusing on the methodological characteristics of Living Labs, this for general Living Lab operations as well as for Living Lab cases running in these Living Labs, and highlighting the similarities with quasi-experiments. We will do this by abstracting the defining elements from Living Lab infrastructures and from Living Lab cases running on these infrastructures. The resulting methodological model will be validated with an in-depth case study of LeYLab, a fibre-to-the-home Living Lab infrastructure with a panel-based approach in which several Living Lab cases took place following a Living Lab methodology. Summarizing, we will look at Living Labs from a methodological point of view and analyse the added value of this approach for the different actors participating in the Living Lab.

2 From labs to live in towards Living Labs

Although some earlier uses of the term ‘Living Lab’ are sometimes referred to, generally the concept as it is understood today is ascribed to MIT’s prof. dr. Mitchell, who used it to refer to a real home where the routine activities and interactions of everyday home life can be observed, recorded for later analysis, and experimentally manipulated, and where volunteer research participants individually live in, treating it as a temporary home (Eriksson et al., 2005). Within ‘living laboratories’ such as the MIT PlaceLab, a 1000 square foot lab, located in the USA, with al facilities of a regular home, users are observed, logged and tracked with all sorts of devices, allowing to record all their habits, activities and routines (Intille et al., 2005). Notice the importance of the technical infrastructure that allows tracking and logging all this data. In terms of methodology, this makes the Living Lab an extension of laboratory experiments, aiming to get more accurate and naturalistic user information by having more long-term data and allowing observation of everyday activities. By building and designing the lab to resemble as closely as possible a real home, this kind of Living Lab tries to overcome the problem of the absence of a natural setting associated with traditional laboratory research. In terms of research design, most experimental and quasi-experimental designs contain a pre-test and a post-test that allow to assess the effects of certain controlled variables on the subjects (Campbell & Stanley, 1966). This is combined with observation and data collection during the intervention. This ‘original’ form of Living Labs is being referred to as the ‘American’ vision on Living Labs (Schuurman et al., 2011). In Europe, there are also some famous examples of Living Labs according to this American vision: the Philips Homelab in Holland and the Fraunhofer InHaus in Germany. The StudioHome in the ID-StudioLab of the Delft University of Technology in Holland even moves the furniture and changes the interior to match the outlook of the user’s own home (Pasman et al., 2005). The difference with these Living Labs and many other demo-homes, homelabs and so-called ‘houses of the future’ lies in the human focus of the former, whereas the latter stick to being nothing more than showcases of technology push (de Jong et al., 2008).

In Europe however, the Living Labs movement gained momentum through European policy from 2006 onwards (Dutilleul et al., 2011), as Living Labs were explicitly supported in the ‘Strengthening innovation and investment in ICT research’-pillar of i2010, the EU policy framework for the information society and media (Peltomäki, 2008). However, European Living Labs started to adopt different forms, building further upon a longer European tradition of user involvement, with e.g. the ’social experiments’ in the 1980s (cf. Oestmann & Dymond, 2001), the Scandinavian tradition of user involvement in design processes (Ehn, 1989) and the ‘Digital City’-projects in the 1990s. One of the more widespread definitions of Living Labs in this European sense describes them as experimental platforms that function as eco-systems where the user is studied in his or her everyday habitat and subjected to a combination of research methodologies while they test new technologies that are still in development (Niitamo et al., 2006). Compared to the American vision, aimed at collecting user data in an unobtrusive way in a natural setting, European Living Labs were more focused on collaboration and the testing of innovation. This also meant that Living Labs were taken out of the context of an actual 'lab' and that Living Lab research activities were transferred into the actual natural and everyday contexts. This momentum also resulted in the development of several international organizations gathering Living Lab-initiatives in order to share methods, findings and best practices, of which the European Network of Living Labs (ENoLL) is the most influential (cf. ENoLL, 2007).

In terms of methodological set-up, this also implied a different approach compared to the American Living Labs. Instead of bringing users to testing facilities, the testing facilities had to be somehow brought to the users. Pierson & Lievens (2005) identified five stages in the process of configuring a Living Lab, based on an analysis of international Living Lab cases and:

- **contextualization**: an exploration of the technological and social implications of the technology or service under investigation; technological scan and state-of-the-art study
- **selection**: identifying potential users or user groups; this can be done on a socio-demographic level, based on selective or criterion sampling, allowance for theoretical variation of previously defined concepts
- **concretization**: an initial measurement of the selected users on current characteristics, behavior and perceptions regarding the research focus, in order to enable a post-measurement;
- **implementation**: the operationally running test phase of the Living Lab; research methods: direct analysis of usage by means of remote data collection techniques (e.g. logging), indirect analysis based on e.g. focus groups, interviews, self-reporting techniques…
- **feedback**: an ex-post-measurement of the users (same techniques of initial measurement) and a set of technological recommendations from the analysis of data gathered during the implementation-phase.

Note that these pre- and post-measurements of the users stress the ability of a Living Lab methodology to assess changes in attitudes, habits, practices,… regarding the innovation in development and allows to uncover the 'added value'. Reflecting back to the original American notion of Living Labs, this methodological set-up remains very similar to the traditional quasi-experimental design. The first three stages can be considered as the 'pre' stage, the implementation phase as the 'intervention' and the feedback phase as the 'post' stage, with the difference that this is carried out in a non-laboratory or real-life environment.

Table 1 Methodological design Living Lab research

Pre-test	*Intervention*	*Post-test*
- Contextualization - Selection - Concretization	- Implementation	- Feedback

Summarizing, this European interpretation of Living Labs led to a more open definition, both in terms of infrastructure as well as methodology-wise. Letting go of the lab-infrastructure meant that the Living Lab infrastructure had to incorporate solutions to capture user behaviour or that this real-life context had to be captured through the adopted research design. Also, the European policy support and the large amount of funding reserved for research entitled as 'Living Labs' fostered a lot of initiatives trying to fit under the Living Labs-umbrella and stretching the concept. Within the next section, we will abstract the defining elements of European Living Labs out of the corpus of Living Lab literature from a methodological perspective and make a distinction between a Living Lab constellation and a Living Lab case.

3 Defining elements of Living Labs

A first general defining element of Living Labs, both in the American as in the European notion, is the ability to study users in a **natural setting**. This means that the technical infrastructure resembles the natural environment (in the case of a laboratory setting), that the technical infrastructure allows to capture user behaviour in the user's everyday environment or that the research methodologies enable capturing the real-life context. Frissen & van Lieshout (2004) also stress this natural setting by defining Living Labs as consciously constructed social environments in which the uncontrollable dynamics of everyday life are accepted as part of the innovation environment which enables designers and users to co-produce new products and services. This final part of the definition also points to the next general characteristic of Living Labs: a **user-centric innovation approach**, as opposed to technology-centric innovation. In Living Labs, users are not considered as passive respondents but as active collaborators or co-producers (Ballon et al., 2007; Almirall & Wareham, 2009). Based on an identified problem, a solution is being developed in close interaction with end-users, a process of co-creation aimed at gaining access to the ideas, experiences, and knowledge of these end-users (Ståhlbröst & Bergvall-Kåreborn, 2008; Thiesen Winthereik et al., 2009). This close interaction and active involvement can only be achieved by adopting a **multi-methodological approach**, with quantitative as well as qualitative research methods with the focus on accessing the ideas and knowledge of these users (Eriksson et al, 2006; Niitamo et al., 2006). Another characterizing element of Living Labs are their systemic nature or **innovation ecosystem**, as multiple stakeholders participate directly in the development of an innovation (Pasman et al., 2005). This is stressed in the definition of Feurstein et al. (2008) who define Living Labs as collaborations of public-private-civic partnerships in which stakeholders co-create new products, services, businesses and technologies in real life environments and virtual networks in multi-contextual spheres. Within their study of user-oriented innovation models, Arnkil et al. (2010) propose Living Labs as so-called quadruple helix-models, being public-private-people partnerships (4 Ps). Another element that is put forward is the duration of the innovation process. Følstad (2008) states that this is at least **medium- to long-term** as opposed to one-shot user research (e.g. market research). This already became apparent when uncovering the methodological outlook of Living Lab research in the previous section as an quasi-experimental design with a pre- and post-test, and the capturing of data during the intervention.

A final element that can be considered as essential in Living Lab is the **Living Lab infrastructure**. This rather generic term is given different interpretations in the Living Lab literature. In its most limited form, it is used to refer to the ICT infrastructure that facilitates cooperating and co-creating innovations among stakeholders (Bergvall-Kåreborn et al., 2009). The definition by Schaffers et al. (2009) is the broadest, as they see the Living Lab infrastructure comprising of the distributed, networked Living Lab environment, the users and user communities involved in the Living Lab, the physical technical facilities (devices, networks, sensors,…) and the methods and tools used during Living Lab operations. Schuurman & De Marez (2012) make a distinction between the 'living' infrastructure, being the panel of end-users participating in the Living Lab, and the 'technical' infrastructure. Building further on this distinction, and keeping the previously abstracted general Living Lab characteristics in mind (natural setting, user-centric approach, multi-method and multi-stakeholder), we propose to make a distinction between the material and the immaterial infrastructure. The material infrastructure consists of the tangible assets that are brought in the Living Lab: physical networks, user devices and research equipment. The immaterial infrastructure consists of the non-tangible assets of the Living Lab: end-users, stakeholders and the environment.

Table 2 Living Lab infrastructure

Material infrastructure	*Immaterial infrastructure*
- Physical networks	- End-users
- User devices	- Stakeholders
- Research equipment	- Environment

We propose that the infrastructure as a whole forms the central tenet of the Living Lab constellation and that the five general Living Lab characteristics depend on this infrastructure. This results in the following conceptual model for Living Labs:

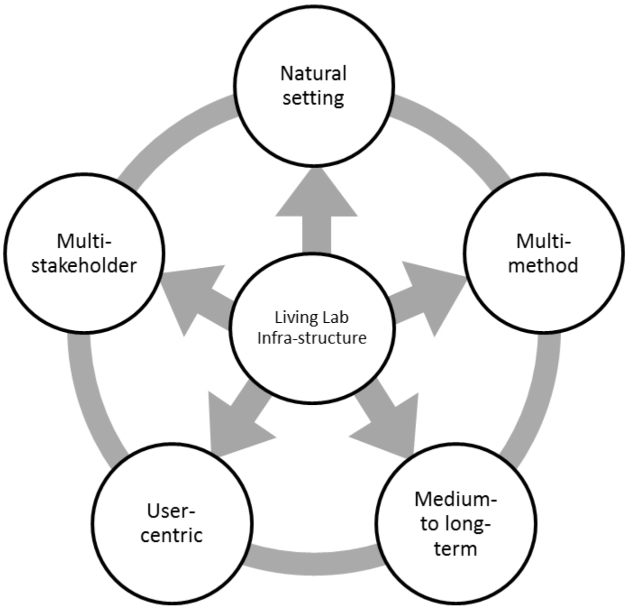

Figure 1 Conceptual model Living Lab constellation

The outlook of our conceptual model of a European Living Lab constellation makes it clear that Living Labs are to be regarded as innovation systems that incorporate both the individual input from end-users (user-centric) as well as the social environment (natural setting) through their multi-methodical and multi-stakeholder approach that takes place on a medium- to long-term basis. This is also advocated in Turkama & Kivikangas's (2009) Living Lab-definition: R&D and innovation with end-users in open, real-life testing environments, where social and institutional factors are as important as technology and economics in driving innovation, and users are integrated since the very early stages of product/service development. This way, an explicit link is established to the 'mutual shaping' and 'domestication' frameworks. The domestication perspective is closely related to the 'social shaping of technology'-paradigm which shifted attention to the content of technology and to the processes involved in innovation, away from the traditional deterministic approaches which took for granted the character and direction of technological advance (Bijker, Law, 1992; Williams, Edge, 1996). The process of integration within everyday's context was initially based on a social deterministic point of view (Jankowski, Van Selm, 2001), but was later corrected towards a more complementary, interactionistic point of view, which proposed that technological advancements shape society, but that society also shapes technological advancements (Punie, 2000). From a research point of view, this called for research both into the adoption diffusion process as well as into the domestication process of innovations (Boczkowski, 2004). By its characteristics and its infrastructure, a Living Lab constellation has the potential to study the domestication of innovations co-created in Living Lab cases, taking into account the dual process between an individual and a social environment, with the individual relying on inner resources (such as memory and intentions) and the social environment providing outer resources. This potential is used when a concrete Living Lab-case is executed in the Living Lab-infrastructure. In theory, a Living Lab constellation can be created and used only once for a given Living Lab-case, a specific type of Living Labs defined by Ståhlbröst (2012) and also described in Schuurman et al. (2011), where a whole Living Lab constellation was put in place for a Living Lab trial regarding mobile TV and disbanded after the project. However, most Living Labs constellations are used for multiple Living Lab cases, which we can visualize as follows:

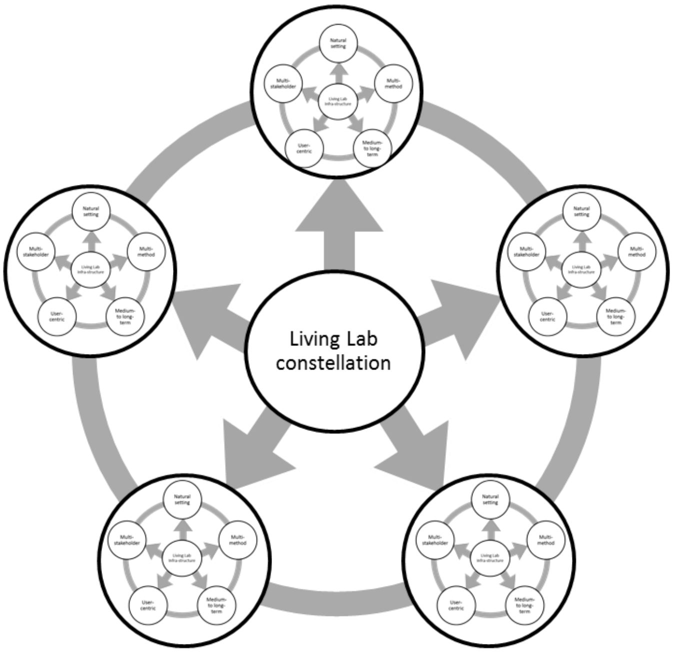

Figure 2 Multiple Living Lab cases in a Living Lab constellation

Based on this model, every single one of these Living Lab-cases makes use of the Living Lab-constellation it is conceived in, following the pre-test post-test design, but having its own set of characteristics and using or not using certain aspects of the Living Lab-infrastructure of the Living Lab-constellation, and possibly adding case-specific infrastructure (e.g. devices, users,…). In order to test this theoretical and conceptual view on Living Labs, we will explore this by means of an in-depth case study.

4 Research design

In the remainder of this paper, we will explore conceptual methodological model for Living Labs by means of an in-depth case study of the LeYLab Living Lab. Yin (1984) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context that should be used when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used. This exploratory method is especially suited for investigating new and poorly understood processes (Eisenhardt, 1989). Seen the complexity of Living Labs as innovation systems, this method seems appropriate. Within our case study, we take a methodological perspective to study the phenomenon of Living Labs as innovation systems, divergent from any of the previous studies on Living Labs. We will do this for the LeYLab Living Lab and the various cases that have ran within this Living Lab over a time span of two years, the formal duration of the Living Lab.

For our analysis we were able to use the following data sources as first-hand involved actors in the Living Lab operations and Living Lab cases:

- official meeting minutes of all steering committees and of all official work package meetings
- the initial project proposal and all project reports
- all deliverables from the Living Lab operations and of the Living Lab cases and all Living Lab-cases
- all data from user research regarding Living Lab operations (intake surveys, domestication interviews,...) and regarding the Living Lab cases
- fields notes of all Living Lab-cases meetings
- data from a short survey that was held amongst all actors participating in the Living Lab at the end of the Living Lab, which took more or less the form of a SWOT-exercise
- open-ended interviews with all actors regarding the SWOT-exercise

5 Results & discussion

5.1 Living Lab-constellation

LeYLab (www.leylab.be) was a **Living Lab-constellation** situated in Flanders, Belgium which offered fibre internet access to a panel of households and organizations. This Living Lab was set up in September 2010 following the public call in Flanders for Living Labs with 'Converged Broadband Access networks' as central theme and was subsidized by IWT, the Flemish public investment organization for innovation and science. The Living Lab was operational by July 2011 and its fibre network was located in two geographically restricted areas (city areas Buda and Overleie) in the City of Kortrijk. By building a Living Lab environment for Next Generation Access (NGA), based upon fibre, testing innovative applications and services was made possible. Fibre offered unprecedented test facilities, in terms of bandwidth and quality of service, and aimed at stimulating the ICT sector to develop innovative applications. Therefore, the shared goal of LeYLab was to stimulate innovation and to measure the relevance of new services for the personal lifestyle and living environment of the test users. Two main topics were chosen as focus for the Living Lab: innovative media and eHealth. Besides the fibre-internet, some panel members also received a tablet and some received a miniPC to consult internet services on their TV-screen.

In order to set-up the Living Lab innovation network, a consortium of eight private partners was composed with three public organizations and one public authority.

Alcatel-Lucent (www.alcatel-lucent.be), a multi-national technology company, took the project lead and provided the necessary equipment for the in-home usage of the fibre connection (modem, router,…) and was responsible for the monitoring of the network (logging) and for the integration of all services and devices within the network. **Belgacom** (www.belgacom.be), the largest telecom provider in Belgium, deployed the fibre infrastructure and supervised the network. This was facilitated by the **City of Kortrijk** (www.kortrijk.be) who enabled the permits needed to install the network, started the communication loop with the potential test users and engaged local stakeholders for the Living Lab initiative. All research activity, panel recruitment and panel communication was executed by the **iMinds** (www.iminds.be) research institute. These four parties were active in both thematic domains and can be considered as responsible for the general Living Lab operations. Regarding the deployment of the network, a necessary precondition for all Living Lab operations and eventual Living Lab cases, this took much more time than expected. Time and effort for convincing people to participate and for effectively putting the fibre in the ground and installing the necessary devices in the homes of the users were underestimated by the consortium partners.

The other actors from the consortium could be allocated to one of the thematic domains, as they were involved in one of the two thematic use-cases that were predefined before the Living Lab was set-up. These use-cases were meant to provide applications to the test users, so they could start testing, and as showcases to attract external utilizers to the Living Lab. **Zeticon** (small university spin-off with media asset management system, www.zeticon.com), **Videohouse** (medium-sized AV technology provider, medium-sized company, www.videohouse.be) and **Focus WTV** (medium-sized regional broadcaster, SME, www.focus-wtv.tv) were gathered to set-up an innovative media database allowing to share and archive multi-media content through the fibre network. **Androme** (medium-sized ICT support, www.androme.com), **In-Ham** (small public sector organization concerning eHealth, www.inham.be), **U-Sentric** (medium-sized university spin-off specialized in usability testing, www.usentric.be), **OCMW Kortrijk** (public health organization from the city of Kortrijk) and **Televic Healthcare** (medium-sized eHealth technology company, www.televic-healthcare.com) were involved to develop the eHealth thematic side of the Living Lab by enabling remote communication through the TV or other devices between healthcare workers and people in need of healthcare.

However, besides the slow deployment of the Living Lab infrastructure, both use-cases also suffered from various other difficulties. These resulted in the media case being up and running only during the final month of the Living Lab and the eHealth use-case not being implemented at all because of difficulties integrating the solution on the fibre infrastructure and because of the lack of panel members who needed healthcare.

The aforementioned issues regarding the general Living Lab operations also affected the generation of **external Living Lab cases** as the lack of cases and research material made it hard to convince external utilizers to come to the Living Lab. Eventually, three external Living Lab cases ran in the Living Lab: **Poppidups** (a virtual puppetry application playable online with cards containing a unique QR-code), **Cloudfriends** (a network optimization application that also included WiFi configuration based on user feedback) and **WeePeeTV** (an over-the-top streaming TV application). In all three cases users were involved in testing, evaluating and co-creation of the innovative applications.

Table 3 LeYlab infrastructure

Material infrastructure	*Immaterial infrastructure*
- Fibre network	- 98 households & 17 local non-private connections
- Modems, tablets & miniPCs	- 12 consortium partners & 3 external utilizers
- Logging infrastructure	- Local area in the city of Kortrijk

5.2 Living Lab-cases

Within LeYLab, the Living Lab-constellation, six major Living Lab cases were conceived. We will now briefly review these cases and analyse whether they benefitted from the Living Lab-constellation and how they evolved in terms of methodology.

The first case involved Belgacom and Alcatel and concerned the roll-out and usage of the infrastructure itself. By surveying the end-users before they were connected to the fibre network and at the end of the Living Lab, differences in attitude and usage could be assessed, as well as interest in the technologies. During the intervention, the usage of the end-users was monitored closely by Alcatel, which resulted in a segmentation of the households based on actual usage. These findings were complemented with personal interviews and with the survey data, providing a fine-grained picture of the domestication of the fibre-internet and the resulting behavioural changes. This case benefitted optimally of the infrastructure of the Living Lab-constellation.

The second and third case were also ‘internal cases’ of consortium members: the media and the eHealth-case. Both suffered from the slow roll-out of the infrastructure and encountered serious issues getting up and running on the fibre-infrastructure. When the media-case eventually was integrated with the network, it benefitted from the material infrastructure as the fast network enhanced the user experience (especially for uploading media) and consultation on multiple devices (tablet, TV) was possible. The locally embedded user community was also interesting for sharing media regarding local events. The city of Kortrijk was also an important stakeholder in this case as they held a call-to-action for assembling local media content. The fact that this case was only up and running at the end of the Living Lab, made it impossible to assess the added value of the media service, so the case was not completed. The eHealth-case also suffered from network issues, but did not match with the user panel either (immaterial infrastructure). The users engaged in LeYLab were not interested in the eHealth application and even with the facilitating role of the city, looking for an external partner in the local ecosystem to test the application, no interested parties or end-users were found. For the eHealth case, the Living Lab infrastructure did not match well.

From the external cases, Cloudfriends benefitted most from the technical infrastructure, albeit in a negative way, as this application dealt with network problems. Because most connected households also had their own internet connection, a lot of network conflicts occurred, which was ideal to test this application. Through the contacts with Lead Users from the testing panel (immaterial infrastructure) and by integrating the solution on the network (material infrastructure) Cloudfriends slightly shifted their focus and also included WiFi-access and –control as a functionality. This resulted in the technology being sold to an international company, making this case definitely a success for the external utilizer. For both the Poppidups and the WeePeeTV-cases, the pre-test phase was conducted with a larger user panel because both companies wanted a broader assessment of their innovation than the hundred households in LeYLab. For the roll-out of the WeePeeTV set-top-boxes, the panel members of LeYLab were used because these households were all in the same area and were motivated to test the technology, making it easier to install these boxes. The streaming service also benefitted from the fibre internet connection, so we can conclude that for this case, both the material infrastructure (fibre network and tablets) and the immaterial infrastructure (motivated test-users in a geographical area) had added-value for the Living Lab-case. For the Poppidups case however, the roll-out also involved mostly users that were not LeYLab panel members, as the devices needed for Poppidups were regular home devices (computer and webcam), no extra bandwidth was needed and the playing cards with the QR-codes were sent by mail. The only benefit was a separate field trial, conducted in a school that was connected to the LeYLab-network and that was easily motivated to try out the innovation.

6 Conclusion

Within this paper, we have proposed a methodological view on Living Lab-research which shows that this resembles the design of quasi-experiments with a pre-test, intervention and post-test. For the European translation of Living Labs, we distinguished five main characteristics: a natural setting, a user-centric, multi-method and multi-stakeholder approach, and a medium- or long-term timeframe. These characteristics were determined by the Living Lab-infrastructure, consisting of material (network, devices and research equipment) and immaterial (stakeholders, end-users environment) elements. All these elements together form the Living Lab-constellation in which different cases can take place following the methodology for Living Lab-research.
From our in-depth case study of the LeYLab Living Lab we could learn that our proposed conceptual model was able to capture the actual operations and cases running in the Living Lab. However, it appeared that a heavily infrastructure-driven Living Lab imposes some risks, such as the roll-out which can take longer than expected and the integration of external cases with this network. All three of them can be situated in the media and ICT domain, whereas no further eHealth cases were rolled out. This stresses the need for a clear thematic focus for the Living Lab-constellation, which makes it easier to define internal Living Lab-cases and to attract external utilizers of the Living Lab-infrastructure. However, this work is still exploratory and preliminary in nature. Future research should look more deeply into the relations between the different elements of the infrastructure, the different cases and the influence on the overall Living Lab-constellation.

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