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Developing a quasi-experimental research design framework using analogue observation to evaluate the performance of a Living Lab output

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Abstract

Since its introduction in the nineties, the concept of Living Lab has evolved from a space where technological innovations is tested directly by users for an innovation eco-system. The creation of the European Network of Living Labs (ENoLL) in 2006 characterizes this evolution. Although Living Lab are well disseminated around the world, there is a lack of consensus on how a Living Lab should be organized (macro level), which types of projects are considered as Living Lab projects (meso-level) and which methods should be used (micro level) (Schuurman, et al., 2015). Furthermore, Living Lab need tools to evaluate the performance of its output (Schuurman, et al., 2015). Therefore, we developed here a quasi-experimental research design framework using analogue observation to evaluate the performance of a Living Lab output. In this paper, we illustrate how to operationalize this research design framework in a case study that aims at introducing Autonomous Vehicles (AVs) in a city in Switzerland.

Key words: Living Lab, Quasi-Experiment, Analogue observation, R&D for Services, co-design, empowerment

1 Context

The concept of Living Lab was introduced in the nineties at MIT in the US. Originally, a Living Lab was a space where technological innovations used to be tested directly by users (Dvarioniene, et al., 2015). Thanks to these infrastructures, researchers had the opportunities to collect data about the use of their novel technologies as well as users' perceptions. Since this first experience, the concept of Living Lab has evolved to an innovation eco-system and is now an essential trend in innovation development. This evolution is characterized by the creation of the European Network of Living Labs (ENoLL) in 2006. Today, ENoLL counts more than 150 active Living Labs worldwide[1].

[1] https://enoll.org/about-us/

As Schuurmann (2015) defined it, three levels characterized a Living Lab: 1) macro level, the ecosystem, 2) meso-level, the project and 3) micro level, the tools. Another characteristic of a Living Lab is the involvement of stakeholders in all categories, as shown in the quadruple helix: users, companies, academics and public authorities[2]. Finally, the user involvement during the whole co-design process is the most important characteristic of a Living Lab (Schuurman, et al., 2015).

Although the Living Lab concept is well disseminated around the world, there is a lack of consensus on how a Living Lab should be organized (macro level), which types of projects are considered as Living Lab projects (meso-level) and which tools are used (micro level) (Schuurman, et al., 2015). Furthermore, the Living Lab initiative need tools to evaluate/assess the performance of its output (Schuurman, et al., 2015).

A Living Lab approach is also described as “an Open Innovation ecosystem” were users are involved in the R&D process (Pallot, et al., 2010). R&D projects are conducted in a laboratory (in vitro). For their part, Living Lab projects are conducted in natural environments (in situ). Therefore, we propose to structure Living Lab projects (meso-level) as a Research and Development (R&D) function. In addition, given that one of the six perspectives typifying a living lab is service creation (Mulder, et al., 2008), we will used the concept of R&D for services. As R&D projects use experiment to support, validate or refute a hypothesis, we propose a quasi-experimental research design framework using analogue observation (micro-level) to assess causal impacts related to an intervention by using empirical testing protocols. This tool enables to evaluate the performance of a Living Lab output.

This paper is organized as follows. In Section 2, we present a literature review related to the evolution of Living Lab (macro level), R&D for services (meso level) and evaluation methods (micro level). In Section 3, we describe our methodological development of a quasi-experimental research design framework using analogue observation to evaluate the performance of a Living Lab output. In Section 4, we illustrate how to operationalize this quasi-experimental research design framework. The presented case study is based on a project who aims at introducing Autonomous Vehicles (AVs) in a city in Switzerland. As an example, we will test the hypothesis that the use of Autonomous Vehicles (AVs) improve the mobility of people with disabilities. Finally, in section 5, we discuss our proposition and provide directions for further development.

[2] ENoLL Application Guidelines - 13th Wave on https://fr.scribd.com/document/397044439/ENoLL-Application-Guidelines-13th-Wave

2 Literature review

2.1 The evolution of Living Lab and the need for methodology to assess performance

Since the Helsinki Manifesto (2006), the European Living Labs start to structure their innovation efforts and methodologies (Mulder, et al., 2008). Mulder and her colleagues first try to harmonize the methods and tools used in Living Labs. As in other methodologies for innovation like Design Thinking and Service Design, there is not one way to foster innovation (Brown & Katz, 2011; Schneider & Stickdorn, 2011; Fragnière, et al.,2012), but an agreement on several principles like, the end-users participation in each phase of the co-design process, the stakeholder involvement (Mastelic, 2019) and the goal to foster a better society. However, there is a need to find appropriate methods to assess the performance of a Living Lab, especially of its output (Schuurman, et al., 2015). The Living Lab harmonization cube does not propose explicitly methods and tools to assess the performance of a Living Lab output (Mulder, et al., 2008).

2.2 R&D for services – A way to structure and measure innovation

In the Oslo Manual, innovation is defined as “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (OECD, 2018, p. 20). A key tenet of the Oslo Manual is that innovation can and should be measured. Therefore, it “provides guidelines for collecting and interpreting data on innovation. […]” (OECD, 2018, pp. 19, 20).

Pallot, et al. (2010) described the Living Lab approach as “an Open Innovation ecosystem” were users are involved in the R&D process. A Living Lab can be seen as a “Living Laboratory”, at the level of a region, in which users participate in the development of innovative goods and services (co-design). Its main goal is to explore the insight, the salient features valued by a specific population and to co-create value together. It is also a test environment, open and benefiting from technological and methodological tools. It is, therefore, an ecosystem allowing a participatory process, using appropriate tools and methodologies (Liedtke et al., 2012).

The Frascati Manual (2015, p. 28) defined R&D as “creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.” The new edition of the Frascati Manual put a greater emphasis on the R&D in the social sciences, humanities and the arts (2015, p. 44). However, the R&D for services process is not formally organized as in other industries (Miles 2007, Sundbo 1997). Sawatani and Fujigaki (2015, p. 166-168), propose a Service R&D Model based on the Service-Dominant logic and extended Moeller’s model where “service processes are divided into facilities, transformation and usage with three spheres, such as R&D, value co-creation and site”.

“The classic process of manufacturing innovation follows three steps in a linear manner: research, R&D and finally manufacturing.” This process cannot be strictly followed for service innovation because service “raw material” is knowledge (explicit and implicit) and customer is also co-producer. In addition, “R&D for production is based on the “make-to-stock” principle. The goods are produced in batches, then stored and finally sold in the markets.” (Fragnière, et al. 2018). This is not possible for services, because services are perishable, instantaneous (Lovelock & Gummesson. 2004) and co-produced, e.g. the learning and practice of music instrument is not possible without the participation of the professor and the student.

The iterative Living Lab process – 1. co-creation, 2. exploration, 3. experimentation and 4. evaluation - (Task, et al., 2017) differs from the R&D process only in the co-creation component, “which breaks the linearity of the process and involves every stakeholder taking part in the innovation” (Fragnière, et al. 2018). “Exploration, experimentation and evaluation have the same similar roles and purposes as the identification of needs, prototyping and testing in the classical R&D manufacturing process”. Fragnière, et al. (2018) propose a model that combines the Living Lab process with the classical R&D process (see Figure 1).

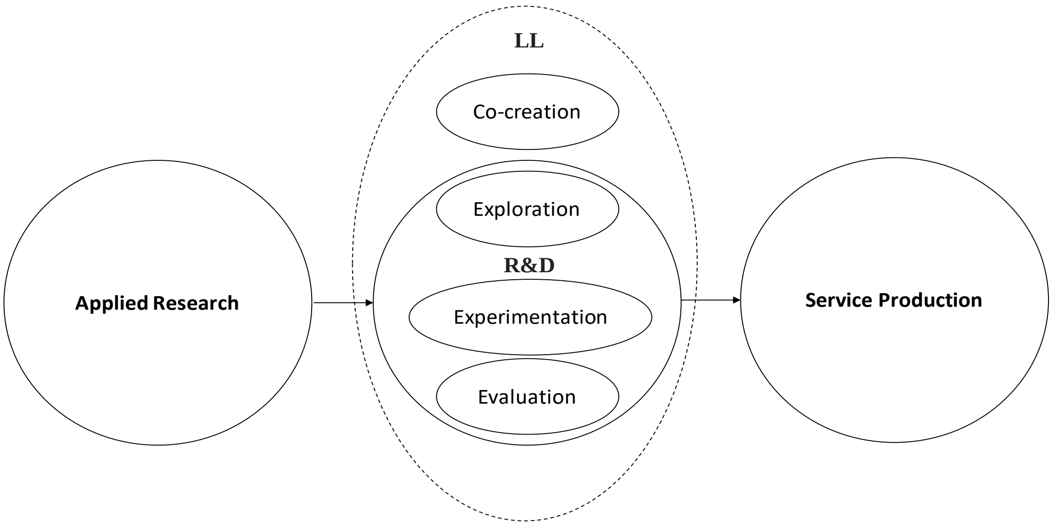

Figure 1. Integrating Living Lab methods in the more formal R&D process

To structure Living Lab projects (meso-level) as a R&D function could contribute to a better comprehension and acceptance by all stakeholders. Indeed, security, safety, compliance or social acceptance are attributes that this rigorous and systematic (i.e. scientific) process can bring to this innovation ecosystem. Furthermore, this scientific framework facilitate the use of scientific procedures like quasi-experiment. Given that, one of the six perspectives typifying a living lab is service creation (Mulder, et al., 2008), we propose to use the concept of R&D for services.

2.3 Evaluation Methods for Living Lab outputs

Impact evaluation relates to the analysis of the causal effect of an intervention. It is linked to the notion of counterfactual analysis. The outcome has to be compared with a sample without intervention (Ballon, et al., 2018) and the developed intervention must create value for its intended users (Ståhlbröst, 2012). In this subsection, we will list some evaluation methods previously used for Living Lab outputs.

In the field of Information & Communication Technologies and smart home technologies, many research projects run experiments in Living Lab environments. In these physical spaces (room, building or district) artefacts (devices, technologies or services) are tested by users with or without their direct intervention (Bendavid, et. al, 2012; Budweg, et al., 2012; Buhl, et al, 2017; Flammini, et al., 2018; Perentis, et al., 2017; Schuurman, et al, 2011;). With the emergence of user-centered design in the late 1980, “Usability evaluation with real users became a key part of product development” (Nielsen, 1994). Qualitative and quantitative data collection techniques are used to assess the effectiveness of technologies (Bassoppo-Moyo, T. C.,2010).

To assess the users’ acceptance of a Zero Emission Building in the Trondheim Living Lab, Korsnes, et al. (2017) used a quasi-experiment design, qualified by the authors as a variant of a qualitative experiment. The authors collected data through a mix-method approach in which qualitative data is complemented by quantitative data like the measurement of energy consumption or the outside and inside temperature.

3 Methodological Development

3.1 Quasi-experiment

An experiment is, according to William Ralph Inge, “a test under controlled conditions that is made to demonstrate a known truth, examine the validity of a hypothesis, or determine the efficacy of something previously untried” (Shadish, et al., 2002).

Schuurman et al. (2013) propose a quasi-experimental approach for Living Lab projects. To this end, they include a pre-measurement, an intervention (a real-life experiment) and a post-measurement. For them, evaluation phase can be seen as “the assessment of the impact of the experiment with regards to the current state in order to iterate the future state” (Task, et al., 2017). It enables to generate a “post-measurement of the intervention and compare it to the ‘pre-measurement’ benchmark, illustrating the potential impact and added value created by the innovation” (Task, et al., 2017).

3.2 Naturalistic and analogue observation

“Naturalistic inquiry differs from conventional science in minimizing constraints on antecedent conditions (controls) and on output (dependent variables). Naturalistic inquiry is phenomenological rather than positivists" (Guba, 1978). When the experimental approach is implausible, it offers an alternative for researchers. In a naturalistic experiment, data is collected under natural conditions, i.e. not in the lab (Guba, 1978).

The naturalistic observation relates here mainly to the field of human ethology, especially for the case of experiments (Eibl-Eiblsfeldt, 1989). Actually, the ethological experiment falls into the category of quasi-experiment. It means that we are not able to control all the variables present in the experiment, as it is the case with pure laboratory experiments. Our goal is not to generalize findings but rather to discover new behavioural patterns. There is also no standardized approach. In a Living Lab setting, Fragnière et al. (2017) used naturalistic observation and ethogram to test their hypothesis that queue structuring can have a positive impact on wait time perception. In a Living Lab context, analogue observation could be more appropriated (Norton & Hope, 2001).

3.3 A quasi-experimental research design framework using naturalistic to evaluate the performance of a Living Lab output

As the Living Lab output is no more than a set of hypotheses addressing the ways in which users will interact with the service or the object, it can be evaluated or tested through a quasi-experiment with a control group and an experimental group. In a quasi-experiment, participants are not randomly assigned to a case (Shadish et al., 2002), after which the results of the two groups are compared (Campbell & Stanley, 2015). Knemeyer and Naylor (2011) have identified the necessary conditions for quasi-experiments to establish the causality of two tested variables. First, with all other things being equal, solely the independent variable is changed, and second, the independent variable might or not affect the participants, and thus the dependent variable might also change.

We can, however, describe it as a process containing the four following main steps:

- Hypothesis formulation. We start by formulating a hypothesis related to a given human behaviour. This hypothesis is the answer to the stated research question. In a Living Lab process, the hypotheses are formulated during the co-creation and the exploration phase.
- Hypothesis "operationalization". We then "operationalize" the hypothesis through a simulation of the ecosystem under study to obtain a prediction of it. This correspond to the experimentation phase of the Living Lab process.
- Data collection and analysis. We collect and analyse the data of the experiment (e.g. a simulation of passengers waiting at airport security gates). This is the evaluation phase.
- Conclusion. We compare the statistical results to the prediction and also to other findings in the literature to assess the validity of the hypothesis.

4 The operationalization of the quasi-experimental research design framework - A case study

This case study illustrates how to operationalize the quasi-experimental research design framework. Based on a project who aims at introducing Autonomous Vehicles (AVs) in a city in Switzerland, we illustrate how quasi-experiment could be designed according to our R&D service approach to be able to test hypothesis related to use of Autonomous Vehicles (AVs) for improving the mobility of people with disabilities and reduced mobility. This case study shows how the quasi-experimental research design framework we develop would structure such a problematic. We focus here solely on the aspect of the framework and not on the statistical tests of the quasi-experiment.

4.1 Context of the case study

4.1.1 The challenge of autonomy of people with disabilities and reduced mobility

One of the numerous challenges faced by people with disabilities and reduced mobility is the accessibility of public space. Improving the mobility of people with disabilities give them autonomy and reduce the risk of social isolation (Simplican et al., 2015). The mobility of people with disabilities is much more than a technological challenge. Indeed, regarding our ageing society, it is a necessary and crucial democratic debate and a process of empowerment (Lord & Hutchison, 1993).

“In the mobility sector, a large number of new technologies such as autonomous vehicles (AVs) and services are emerging. AVs involve not only passengers, but also authorities, manufacturers, public transportation companies, law enforcement officials, drivers, pedestrians and merchants” (Ramseyer, et al., 2019). For people with disabilities, the introduction of autonomous vehicles (AVs) as public transportation represents a challenge. The objective is to deliver a much better quality of life by identifying and providing opportunities for better social inclusion. Furthermore, it will be necessary to better define the city's general traffic plan and the appropriate layout of pedestrian streets tacking into account the need of people with disabilities while integrating these new means of transportation. Therefore, it is important to design transportation modes that take into account the needs of people with disabilities.

For a successful implementation, the service provided by a new technology must be a relevant problem solving that changes the users’ life. As such, new services must be pre-tested and validated by users not only on performance measures but also on perceptions. Therefore, it is essential to take into account the factors that will affect the adoption and user acceptance of these novel systems and to integrate as well the felt needs of people with disabilities (McCreadie & Tinker, 2005).

4.1.2 A Swiss Living Lab dedicated to handicap

In Switzerland, about 1'300'000 people find themselves with a handicap[3]. Switzerland as adopted in 2014 the Convention on the Rights of Persons with Disabilities[4]. This convention is an international agreement that in principle guarantees people with disabilities the equality of experience in all areas of citizenship (Darcy, 2012). Furthermore, the laws of the Swiss Confederation dictate equal opportunities for all. Particularly, the Federal Act of 13 December 2002 on the elimination of discrimination affecting persons with disabilities (Disabled Persons Equality Act - LHand) provides remedies and rights of legal action to make it easier for individuals with disabilities to assert their rights.

In 2018, the HES-SO Valais-Wallis and the Innovation Centre for Assistive Technologies (IATLab) founded the Living Lab Handicap (LLH) with the collaboration of ASA Handicap Mental and the Foundation for Research in Favour of People with Disabilities (FRH). This initiative connects people with disabilities, their families and caregivers, with scientists, companies, public authorities and all the other stakeholders (care institutions, charitable associations, etc.) interested in collaborating in the field of disability and the co-design of innovative solutions. "Nothing About Us Without Us.[5]" This sentence perfectly illustrates the vision of this Swiss Living Lab. Being at the center of the co-design process and the vision of empowerment, participants will elaborate with all the stakeholders detailed scripts in order to co-design adequate and useful products.

4.1.3 Autonomous vehicles on public road in Switzerland

In the city of Sion in Switzerland, AVs are in function since 2016 on public road (Eden, 2017). The pilot project of AVs begins in the summer of 2016 in the old city of Sion. In 2019, two routes are in function. The first conducts passenger from the rail station to the old town. The second drives in the old town. The AVs are in function from Wednesday to Sunday from 7 to 10 am and from 1 to 6 pm. The goal of this pilot project is to understand if AVs could offer new services and forms of mobility in regions currently deprived of public transport and to test if the introduction of autonomous shuttles in the public space is technically and operationally feasible, while offering added-value to customers.

[3] https://www.bfs.admin.ch/bfs/fr/home/statistiques/sante/etat-sante.assetdetail.7347551.html
[4] www.humanrights.ch
[5] https://en.wikipedia.org/wiki/Nothing_About_Us_Without_Us

4.2 Quasi experiment framework implementation

4.2.1 Hypothesis formulation

People suffering from reduced mobility primarily use wheelchairs. According to the World Health Organization (WHO), the prevalence of disability ranges between 12 - 18% of the total population and the majority of people with mobility issues use wheelchairs[6]. Our quasi-experiment test the hypothesis that the use of Autonomous Vehicles (AVs) improves the mobility of people with disabilities.

4.2.2 Hypothesis “operationalization”

To operationalize this hypothesis – the use of Autonomous Vehicles (AVs) improves the mobility of people with disabilities – we recruited three users with reduced mobility who used wheelchair. The three users had to use the AV in the Sionold town route.

4.2.3 Data collection and analysis

In the AV, only one user in wheelchair can embark at the same time. The experiment was run three times. Each time, two same observers collecting data during the whole experiment accompanied the three different users. The collected data are pictures, movies, observation notes and phenomenological quotes. Then, this data are analysed with the help of software like RQDA and NVIVO.

4.2.4 Conclusion

Even if this case study is solely used to illustrate how to operationalize the quasi-experimental research design framework, the collected data are interesting. Indeed, without the help of a third person, it is impossible for a people with disabilities to use the AV. The ramp to embark and disembark has to be installed manually (this feature will be automatized in the next generation of AVs) and is too steep. Furthermore, in many bus stops it was impossible for the user to embark or disembark due to the lack of space between the bus and an obstacle (e.g. building). Consequently, here based on these results, we are not able to confirm the hypothesis that the use of Autonomous Vehicles (AVs) improves the mobility of people with disabilities. However, our goal here was just to show how our R&D for services framework can be operationalized in a handicapped Living Lab to ultimately test the validity and performance of new research hypotheses.

[6] WHO. (2017b). World report on disability. http://www.who.int/disabilities/world_report/2011/report/en/

5 Discussion

Even if Living Lab is now an essential trend in innovation development, the initiative need tools to evaluate the performance of its output (Schuurman, et al., 2015). In this paper, we proposed to structure Living Lab projects (meso-level) as an R&D for services. This rigorous and systematic framework permits the scientific validation of operationalized hypotheses through quasi-experiment protocols. In particular, we developed a quasi-experimental research design framework using analogue observation (micro-level) for the evaluation of a Living Lab output performance.

In the case study, we illustrated how to operationalize the quasi-experimental research design framework. Our quasi-experiment was designed to test hypothesis that the use of Autonomous Vehicles (AVs) improves the mobility of people with disabilities and reduce mobility. Even if this case study is solely used to illustrate how the quasi-experimental research design framework we develop would structure such a problematic, results here could not confirm our starting hypothesis.

For a Living Lab manager, this quasi-experimental research design framework using analogue observation do not require much efforts and specific competences (e.g. statistics). However, it is efficient and answers an important question: do the living lab output solve a problem for the users and improve their situation? Furthermore, the observation data collected during the quasi-experiment also represents insights for a new co-creation iteration.

Even if these results based on qualitative data are interesting, the use of quantitative data will be complementary. In future work, we will use quantitative data collection techniques to reinforce our quasi-experimental research design framework in order to enhance our results through statistical testing

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