Future Labs: Making the Future Tangible Today

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Abstract This chapter summarizes the important knowledge of open innovation (OI), Design Thinking (DT), and living labs (LL). It highlights the need for collaboration and co-creation among stakeholders from different backgrounds, perspectives, and experiences to co-generate new business opportunities. The role of users in the innovation process is emphasized, with the concept of user-driven innovation and participatory design being crucial. The authors also introduce two case studies, iHomeLab and KTH Live-in-Lab, as examples of living labs and field tests that enable testing of innovative technologies and methods in real environments. The feasibility of innovation in human, technical, and economic domains is highlighted, and the potential of technology, data security, ethics, and new processes for enhancing innovation capabilities is mentioned. Overall, the chapter sets the stage for discussing the importance of openness, collaboration, and user-centric approaches in the future of innovation.

Many theories explain the nature of innovation and point to practical applications. This topic is broad and can be considered from different angles and at different levels. However, the percentage of innovative ideas implemented in life is still relatively low. For example, only one in 3000 innovative ideas in the ICT sector reaches the market (EU Commission). This means that considerable efforts to create something new remain unrealized. The reasons for such low rates can be interpreted in different ways. One of the reasons that the academic community has been discussing quite seriously lately is the gap between research laboratories and the adaptation of acquired knowledge to the canvas of real life. Some researchers call this phenomenon a Pre-commercial Gap (Macdonald, 2004) or Chasm (Moore & McKenna,

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1999). Today, the academic community is aware of the need to bridge fundamental research and real life and create new forms and formats of research laboratories, such as living labs or innovative laboratories (iLabs). According to (Halila, 2007), to realize an innovative idea in real life, three things are required: a process of integrating new technology into the existing context, a network of actors that connects users of this technology in a new way, and consequentially a new social, economic, and environmental reality shaped by the adoption of the new technology.

Nowadays, we are entering an era that will be defined by the digitization and connection of everything and everyone. This global trend will lead to the emergence of a new global-local socioeconomic order in which digital products and services are offered globally, adapted, and delivered locally. We believe that such new orders should be collectively co-created with a certain degree of transparency, inclusivity, and openness. In these kinds of processes, openness is crucial for the innovation process. It is vital to gather various points of view, which can lead to the successful development and implementation of new ideas and generate new and unexpected business openings. However, to be able to collaborate and share in a multi-stakeholder environment, different levels of openness between stakeholders seem to be a requirement. Eriksson et al. (2005) propose open collaboration between people from different backgrounds, perspectives, knowledge, and experiences to stimulate creativity and create new ideas that can be applied and benefited through use. More people, including consumers, need to be involved in the innovation process. This is argued by Von Hippel and Katz (2002), who stated that users are often the source of innovation. The concept of user-driven innovation (Urban & Von Hippel, 1988) suggests that users are capable innovators. Thus, it can be argued that the participation of end-users or consumers in the innovation process is essential. They should be a vital part of the innovation system.

Participatory and user-centric design ideas are not new, but the level of complexity with which today's developers of future laboratories are confronted demonstrates a qualitatively new level. Over the past decade, industrial innovation labs at public universities, the living labs, and a New European Bauhaus movement have gained momentum. These new formats of future labs testify to the modernization of laboratory infrastructure and the emergence of a new mindset and a culture of innovation where openness, collaborativeness, and democratization are becoming the new normal.

1 Open Innovation

In most research and innovation laboratories, multi-stakeholder platform strategies are becoming one of the key priorities. In the EU's Innovation Union agenda, they are regarded as a crucial part of the common research agenda Horizon 2020. Academia and science are asked to be involved in processes of open knowledge creation, open science, and open innovation (Chesbrough, 2003) referring to different fields like industrial leadership, societal challenges, and science. With an increasing awareness that the traditional model of innovation is becoming obsolete, a new paradigm of "open innovation" (OI) has emerged, connecting internal and external sources of information-rich environments (Chesbrough, 2003). Nowadays, open innovation (OI) plays a crucial role in improving organizational construction and strategic maintenance as well as enhancing the competitive advantage of firms.

The original definition of OI stressed that "valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well. This approach places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths" (Chesbrough, 2003). Both innovation scholars and Chesbrough have modified its original definition, with the latter stressing the intentionality of knowledge inflows and outflows: "Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively" (Chesbrough, 2006).

Open innovation is based on the idea that, within the modern competitive context in which firms have to operate, the linear model of innovation (Urban & Von Hippel, 1988) is no longer able to be applied to the innovation process. Today's organizations have to collaborate with external stakeholders through the iterative exchange of knowledge, technology, and resources across their boundaries (Galati, 2015; Galati & Bigliardi, 2017). In other words, to stay relevant on the market, a single organization cannot innovate in isolation, it has to engage with different types of partners, ranging from companies with the similar visions to customers, universities, research centers, and even competitors (Bigliardi & Galati, 2017), in order to acquire ideas and resources from the external environment (Laursen & Salter, 2006). Open innovation promises to increase internal innovations through the involvement of external parties and the commercialization of new ideas, which can create new value for business. Value creation for the industry is by the commercialization of the latest technology and patents (Chesbrough et al., 2006).

One of the most important transformations, which OI can facilitate, is the conversion of rigid organizational boundaries into semi-permeable ones which enable innovations and knowledge to move freely between the organization and the external environment. These inflows and outflows of knowledge do not spontaneously occur; organizations must generate opportunities and mechanisms for identifying existing knowledge and transferring it into or outside the organizational boundaries (Spithoven et al., 2010).

It is not an easy task to define the degree of the openness of a specific organization. Scholars propose two variables are considered that represent the degree of openness for an organization:

1. The number and type of partners with which the company collaborates.
2. The number and type of phases of the innovation process that the company opens to external contributions.

By crossing these two variables, four basic modes of open innovation are identified: closed innovators, open innovators, specialized collaborators and integrated collaborators (Lazzarotti & Manzini, 2009). Most of the research and innovation labs affiliated to different universities have a higher degree of openness compared to the industrial R&D labs. There are many reasons to explain this phenomenon, one of each is the more open mindset and less competitive culture in the academic community. Creating a culture that values outside competence and know-how is crucial for open innovation practice. The culture of open innovation is built on values such as curiosity, creativity, flexibility, and diversity, because the open dimension requires values such as openness, trust, responsibility, authenticity, and sustainability (Matricano, 2018; Phillips, 2010). Innovation culture has five characteristics: (1) vision, (2) network of knowledge, (3) inspiration and leadership, (4) Freiraeume (which means room for ideas), and (5) creativity and risk-taking (Schumpeter & Nichol, 1934). By this we can conclude that open innovation is a necessary attribute of modern research and innovation labs, which can bring an inclusivity and diversity into the process of new ideas formation. We also agree with Enkel et al. (2009) that the future of innovation processes lies in an appropriate balance between open and closed innovation approaches, because too much openness can lead to a negative impact on companies' long-term innovation success, loss of control, and loss of core competencies, whereas a too closed innovation approach does not serve the demands of increasingly shorter innovation cycles and reduced time-to-market.

Another area where OI can contribute is in dealing with disruptive innovation. The seminal book Christensen 2009 outlined the process by which innovation may disrupt an industry. Taking case studies from fast-paced industries (Hard Disk Manufacturing) and slow-paced industries (Mechanical Excavation), he defines disruptive innovation as being an innovation which leads to a radical shift in the market, where typically most successful incumbents are replaced by new market entrants. The disruption is also characterized by the innovation starting in a new or niche market and then disrupting the larger market when performance and cost becomes competitive. This leads to the innovator's dilemma: the technology which can put you out of business is most likely to be less competitive in your current market, and investments in this innovation decrease your business performance. The question is then how businesses can successfully explore new technologies and markets so as to secure long-term competitiveness in a disrupted market. OI provides a partial answer. Market leaders can investigate new technologies and markets via OI and integrate when they believe the technology is becoming successful. Another part of the answer is provided by living labs. They provide a mechanism to test such innovations and niche markets. A living lab is a prototype market of sufficient complexity to provide real data on how a technology can develop in a co-creation process with consumers and to provide the potential for emergence of unexpected uses of the technology and therefore also support the emergence of new business opportunities.

2 Open Innovation and Living Labs

New paradigms, such as open innovation (Chesbrough, 2003) and living labs operating as a User-Centered Open Innovation Ecosystem (Pallot et al., 2010), bring into the conversation the role of users in the research and innovation process (Peltomaki, 2009). As was mentioned above, OI builds on a value co-creation process with users, and the result is expected to better solve customers' needs. Therefore, users are innovators, co-designers, co-producers, and entrepreneurs regarding new products and services (Pascu & van Lieshout, 2009).

Ballon and colleagues (2005) found that Test and Experimentation Platforms (TEPs) constitute a lot of opportunities for OI and co-creation with the users through participatory design. They identified six types of TEPs, namely prototyping platforms, testbeds, field trials, living labs, market pilots, and societal pilots (Pascu & van Lieshout, 2009). They also gave the following definition for a Living Lab: "An experimentation environment in which technology is given shape in real life contexts and in which (end) users are considered 'co-producers'." Living labs allow firms to involve users in the development of new products, services, or applications in a process of co-creation, because the average user, equipped with the proper tools, is the most suitable candidate to design a product or service (Leminen et al., 2012). Therefore, living labs offer an R&D methodology through which innovations are created and validated in collaborative real-world environments (Eriksson et al., 2006). Living labs bring experimentation out of companies' R&D departments to real-life environments with the participation and co-creation of users, partners, and other parties. Therefore, living lab projects are a specific case of open innovation where companies open up their innovation processes to users or customers (Schuurman et al., 2013), which can be linked to the user innovation paradigm (Von Hippel, 1976; Schuurman et al., 2013). Today, 212 living labs are members of the European Network of living labs (ENoLL). They are geographically located within the enlarged European Union and in other regions such as South Africa, Asia, and South America. All of them have the goal to involve users at the earlier stage of the R&D process not only as observed subjects but rather as a participative force for co-creating value.

Prior studies propose stakeholders as "providers" including educational institutes, universities, researchers, developers, or consultants bringing knowledge and promoting solutions for problems; "users" including end users, customers, or citizens to be studied or involved in innovation activities; and "utilizers" including a company or another organization utilizing achieved results; and "enablers" including financiers or area/city development organizations enabling innovation activities in living labs (Leminen et al., 2012). Furthermore, living lab can be viewed as "an arena for innovation. It is a structure and a long-term societal resource rather than related to a certain project. Within this structural framework, experiences, routines and conditions are built to develop ideas into innovations" (Arvidsson & Mannervik, 2009).

One of the important criteria for the living lab approach is that innovation activities should be carried out in a realistic, natural, real-life setting. Orchestrating realistic use situations and user behavior is seen as one way to generate results that are valid for real markets in living lab operations (CoreLabs, 2007). Relating realism to Checkland's real-world concept (Checkland, 1999) means that the "real-world" situation reflects people's interpretation of their current situation. People's interpretations and how they perceive the situation is related to people's worldview, or what they view as important for them; hence, what is viewed as the reality for one person does not necessarily mean the same for another person. This means that what is important and motivating for one partner is not necessarily important to another partner, which is a rationale for why it is crucial to involve a diversity of perspectives in the innovation process. To facilitate these types of processes, the Design Thinking methods are widely applied in the living labs.

3 Open Innovation and Design Thinking

A former President of the Design Management Institute Lookwood, suggests Design Thinking is "a human-centered innovation process that emphasizes observation, collaboration, fast learning, visualization of ideas, rapid concept prototyping and concurrent business analysis." Mintrom and Lieutjens (2016), whose emphasis is on the targeting market, assert "Design thinkers exhibit curiosity and empathy in their efforts to interpret how target populations engage with their world. They deploy various investigative techniques that have the potential to illuminate problems in new ways and indicate effective client focused solutions." Similar to a marketing approach, Design Thinking foregrounds the wants and needs of consumers, but Curedale (2013) notes that Design Thinking has moved far from being merely a tool in the marketing armory to designing things people actually want. These two definitions are connected with one core principle that Design Thinking is invariably user-centered and founded on some actionable insight. It relies on customer observation and uses visualization as a tool for communication. DT enables the creation of rich ethnographic portraits of customer behavior and trying to identify themes and patterns (unmet or under-served needs) from the observations.

One of the main advantages of the DT process is the ability to move through an innovative project to other areas of the organization based on the skillset of the designers. This kind of openness and flexibility of the method allows you to work with initially insoluble problems and, at the same time, achieve concrete and tangible solutions. This ability can enable collaboration in transforming organizations that want to move from a repetitive, mechanistic model to develop ideas, products, and services more in line with the speed of scientific and technological change (Lindberg et al., 2010).

4 Case Study: iHomeLab

4.1 General Introduction

The iHomeLab is the Swiss research center for building intelligence. It is part of the Department of Engineering and Architecture at the Lucerne University of Applied Sciences and Arts. The iHomeLab team conducts interdisciplinary applied research and consists of 25 computer scientists and electrical engineers, physicists, and mathematicians who research the use of the latest technologies such as Wireless Sensor Networks, Internet of Things, Ambient Intelligence, and Machine Learning to provide energy flexibility, security, and data protection in living spaces. The application-oriented research projects are carried out in close cooperation with partners from industry and business, co-financed by grants, and presented to the public in the iHomeLab Visitor Center. The iHomeLab has been registered with ENoLL as a Living Lab since 2015.

4.2 Reflection on OI and DT in the Context of IHL

With its focus on the interactions between occupants and intelligent systems integrated in their buildings, the DT approach has been fully integrated in the research methodology we apply. In particular, in the focus research area Ambient-Assisted Living (AAL), conducted in over 30 research projects since 2008, this approach has proven to be instrumental in conducting successful projects. The focus of AAL is to use technology to enable the elderly to lead an independent life in their own home. A typical challenge is to ensure that the needs of the solution fit the needs and the situation of the elderly, which have proved to be highly local due to their cultural, language, and demographic dependency. The fact that the elderly are partly technology averse or have problems assimilating new solutions complicates the problem. DT is an essential tool for introducing AAL innovations. It allows researchers to meet the elderly in their context and so better evaluate their needs and possible synergies or side effects of the new solution. We use DT to develop solutions, test them in field tests, and show them in the iHL Visitor center—providing dissemination to the public and potential partners.

Through our applied research projects, the iHomeLab operates as part of an open innovation network, taking the roles of technology provider, scientific investigator, and proof of concept designer. This approach—combining OI with DT—significantly increases the effectiveness of the research projects; however, overall market development is subpar due to its fragmentation, the needs of the elderly being very specific to local demography, society, and culture.

Increasingly, it is obvious that the introduction of a solution is dependent on the individual, their social network (relatives, friends, neighbors), support mechanisms (clubs, social networks, volunteer and professional services), and the local political situation. This means that the suitability of a solution can only be tested in a Field Test/Living Lab. For this reason, the iHomeLab joined ENoLL and applied living lab methodologies for the research projects and dissemination of the results.

4.3 Preliminary Results, Improvement Potential, and Future Visions

The impact of these ideas has been seen in several projects over the last decade. As an example of combining DT and field tests, we refer to the project IWalkActive, which won the AAL award in 2013. This project targeted the mobility of the elderly in outdoor settings. User Input was elicited at the beginning of the project and confirmed in the field trials. The project Relaxed Care showed the need to move a step further than the lab or living lab environment and perform long-term trials in the users' home environment. The typical disadvantage of a field trial to a living lab is the lack of measurement information. As IoT specialists, the iHomeLab is able to compensate for this lack by introducing additional sensors in the home, or as wearables. With this additional information, we can gather sufficient data to put together a complete picture of the user context. Relaxed Care provided a first step. In some projects, such as with Ella4Life or Living Well with Anne, which used an Avatar with a speech interface, the interaction and data collection could be integrated directly in the new technology. In others, such as the project Home4Dem, additional sensors were able to identify the Activities of Daily Living, which in turn maybe processed to allow conclusions regarding the state of mental health of the occupants. Combinations of IoT technologies—environmental and wearable sensors coupled with strict data security and machine learning—enables collection of quantified data regarding the interaction and reaction of the users to the new technologies. This is usually complemented by qualitative data won through interviews. The recent project RESTART has also introduced ChatBot technologies which conduct regular structured interactions with the subjects in order to get an up-to-the-minute picture of the user's subjective experience and yields higher quality data than interviews alone.

Another important trend in the area of AAL is investigating the impact of new solutions on the personal situation and social network in which the elder live, respectively, on how solutions must also be designed with not just the elderly, but also their network as key users. With projects such as Sam and Me or Kith'n'Kin, the role of technology in improving engagement and reducing isolation was investigated. In others, such as CabiNET, the focus was more on how to support the network and thus indirectly support the elderly. Such effects cannot be tested in the lab.

The current technical developments will provide more quantitative and qualitative data regarding the adoption and interaction of users with new technologies. Big Data technology will allow better interpretation and correlation of the data, which should lead to more effective DT and OI processes. We see augmented living labs and field tests as the key to unlocking more innovative processes in the assimilation of new technologies by enabling 360° qualitative and quantitative data collection in the natural environment.

5 Case Study: KTH Live-in-Lab

5.1 General Introduction

KTH Live-in Lab is a platform for accelerated innovation in the real-estate sector and for collaboration between academia and business in Stockholm, Sweden. Most test beds in KTH Live-in Lab are operated in real environments for testing and researching new technologies and new methods (Molinari et al., 2023). The purpose of KTH Live-in Lab is to reduce the lead times between test/research results and market introduction. In this way, KTH Live-in Lab aims to facilitate the advent of the sustainable and resource-effective buildings of the future. KTH Live-in Lab enables testing of products, services, and methods in real buildings, which results in a well-founded basis for changing structures and rules and increased use of new innovative technology. Tests in KTH Live-in Lab led to accelerated innovation.

KTH Live-in Lab encompasses a 300 sqm building permit-free innovation environment with alterable student apartments (Testbed KTH), which enables studies on the future's resource-efficient and sustainable student housing. The KTH Live-in Lab also receives property and user data from 305 common student flats owned by Einar Mattsson (Testbed EM) and from the KTH campus education building owned by Akademiska Hus (Testbed AH).

5.2 Reflection on OI and DT in the Context of KTH Live-in-Lab

The idea of an agile testbed for building-related Cleantech arose from discussions as to how we could eliminate the identified obstacles to increased innovation within the residential and construction sectors. KTH Live-in Lab is based on theory around Strategic Niche Management (SNM) and Multilevel Perspective (MLP) (Berkers & Geels, 2011: Schot & Geels, 2008). Both theories discuss innovation and technology shifts. They argue that players who are actively involved in the innovation process affect, through collaboration, the selection process of new technologies and the future trajectory of research and development. These theories emphasize the importance of demonstration projects, or testbeds, that provide partial shelter for new technological innovations, referred to as technological niches (Rip, 1992; Rip et al., 1995; Schot, 1992, 1998). Dynamic clusters thrive on the ability to test and verify products and services within protected environments known as technological niches

(Kemp et al., 1998). These niches facilitate increased interactions and knowledge transfer among various market participants, thus playing a pivotal role in the success of these clusters.

KTH Live-in-Lab can be used for testing and research in the building sector where inhabitants/users are engaged in product or service co-development and providing feedback to the innovating organizations. Our living lab provides open-innovation environments, which in combination with established open innovation ecosystems and respective stakeholder organizations can serve as an effective platform to foster the development and uptake of innovation in the building sector. We are focusing on the theoretical overlapping between two concepts of co-creation: co-creation as an innovation process as a part of open innovation theory and co-creation as a design process as a part of participatory design theory for the service concept development as a part of new service development theory. A few projects are specifically focusing on DT, such as “Sustainable Food System,” where end-users co-created desirable food-related habits together with home appliances industrial designers and behavioral scientists. In a parallel project called “Kitchen,” the users/inhabitants were involved in the process of redesigning KTH Live-in-Lab layout and together with the professional architects co-develop new co-living and co-learning spaces, which made it possible to rebuild KTH Live-in-Lab layout from 1.0 to 2.0. Another project is “Oura ring and sleeping comfort,” aiming to improve the end-user sleeping quality, while operating the building in a more energy efficient way. This project included a series of participatory sessions with the end users. Currently, we are preparing a new big project called Sustainable Behavior Goals (SBGs) aiming to co-design sustainable everyday behavior narratives together with the users/inhabitants of KTH Live-in-Lab. This project will have a DT mindset as a core.

5.3 Preliminary Results, Potential Improvement, and Future Visions

We want to share a few preliminary results of using KTH Live-in-Lab as a testbed for innovation acceleration. First, the opportunity to engage multiple and diverse actors has enormous potential for cross-collaboration and new ideas formation. The process of open innovation brings a certain degree of transparency to the actors’ network, creating a premise for sharing strategies, co-strategies, co-creation, and closer collaborations. Secondly, the practice of a bi-directional value exchange mechanism between different actors helps to identify both tangible and intangible values and enable better understanding of the relationships between actors, which can benefit the quality of relations and a more sustainable partnership in the future. Here we would also like to highlight that open innovation is a key driver of the diversified value proposition. Both OI and DT contribute significantly to shortening the time of innovation and bringing the concepts and ideas into the test phase immediately. Thus, the declared SNM and MLP methodology works not only in theory but also in practice and creates specific prerequisites for various types of innovations and improvements at all three levels: niche, regime and landscape (Geels & Schot, 2007).

We definitely see a lot of potential to improve OI and DT applications at KTH Live-in-Lab and experiment more with different user engagement models: from "expert's" mindset, where a user is seen as a subject, to more participatory mindset, where a user is considered as a partner. In addition, we would like to highlight the importance of actors' network analysis within a living lab lifespan and explore the innovation lifespan changing within time. Today's living lab process is happening in a more organic way, and a lot of processes happening as a "side effect" could be researched more.

We see the future of research laboratories in considering the laboratory as a service for research, testing, and facilitation of innovation process. The laboratory should become a center of attraction for various research needs: from student projects and start-ups to large companies and international collaborations. It is crucial that the laboratory becomes a kind of market space with various tools and can adapt to the needs of researchers and industrial partners. It is very important to be neutral and open to different actors. The diversity of minds attracts and creates an intellectual Brownian motion.

6 Conclusion

Innovation requires feasibility of the innovation in three domains: Human, Technical, and Economic. Human feasibility means that the innovation must provide a real benefit and be acceptable and usable and fit into the life context of the users. Technical feasibility includes the implementation of the technology, but also the existence of support networks—for power and information infrastructure, user support, and repair organizations. Finally, the solution must be economically sustainable—organizations must provide the necessary goods and services. In our opinion, living labs and field tests augmented by IoT are the only environment complex enough to test all these aspects. In the future, we need to bring this complexity forward in the innovation process—to enable with DT and OI—but without creating a situation so complex that innovation is stifled. New processes, insights, and methods, supported by technology and informed by considerations of ethics and data security, will help us gain insights and recognize potentially successful innovation early in the process. In this vision of the future, technology does not automate or replace DT and OI processes; rather it augments our capabilities to use them.

Today, the topic of democratization of innovation is relevant and essential for discussion and practical application. Concepts such as "privacy by design," "ethical design," and "co-creation"/"co-design" are becoming more and more popular, and most projects in these areas are successful. The ability to maintain a dialogue with both the private and public sectors might significantly increase the chances of technology acceptance, usability, and overall trust. Many companies today look to the future and actively create prototypes of future homes, future cities, and so on. We believe that the future should be co-created. Society should be involved in such a process more actively. Therefore, the Academic Community should play the role of a neutral partner in this complex but exciting process.

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