Master's thesis

An exploration of living labs/city labs through practices in two Copenhagen's spaces

Štefan Doležal

Name:	Štefan Doležal
Student number:	20122600
Name of the program:	Master's programme in Techno-anthropology
Institution's name:	Aalborg University, Faculty of Engineering and Science
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Supervisor's name:	Peter Karnøe Professor, Dept. of development and planning, AAU
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Štefan Doležal (12.06. 1988)

Abstract

The main theme of this thesis is an exploration of living labs/city labs through practices in two Copenhagen's spaces. It is investigated how living labs work with tensions between their ideals of engagement, openness to information and at the same time mobilizing resources to 'pay the rent' and invest in necessary technology they seek. Further, it is explored how objects in the living labs are formed, and how they are enacted in different situations/practices that can be located in different spatialities. Fieldwork is conducted by application of ethnographic methods via interviews and participation in daily activities. The findings contribute the understanding of living labs by extension of studied dimensions and in-depth practice exploration. Recommendation for future research is the application of such broader set of dimensions on a more extensive number of spaces to be able to contribute for better categorization. And involvement on large-scale of digital methods as post-demographics gains more importance.

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1. Introduction

The phenomenon of living labs creates networks of interaction where know-how is spread globally, and outcomes such as technological and practical solutions are produced locally in daily practices. For some the Do It Yourself (DYI) initiative where citizens create what some observers see as alternative solutions as living labs bring a potential challenge of the dominant mass production and distrust inflicted by bigger corporations. Communities of so-called creators and DYI biologist have started to appear, who welcome others to study scientific problems, invent and help each other.[1] The old proverb says *'Give a man fish, and you feed him for a day; teach him how to fish, and you will feed him for a lifetime*.' The members of these living labs are changing from passive consumers of technology. Instead, the notion of local production and exploration of technology is reintroduced. For some idealists, the city lab spaces can contribute to the local environment of the community, create a base for technology enthusiasts to explore, educate the public about technology or improve the user's participation in design practices. That is one of the reasons why small communities of inventors, researchers and enthusiast are formed to bring back the technology in hands of people of all ages from students, hobbyists to elderly people.

A new type of labs is emerging in the cities, city labs that are experimental sites for doing experiments and developing devices. They vary in their approaches, worldview, members and aim. A lot of laboratories caught the interest of entrepreneurs who see a potential to turn it into business. The hype of living lab promises to enter a space with collaborative work with flat structure. These kinds of spaces attract people due to its ease to access the space and use of tools. Base on the nature of space, the members are given a certain freedom to do their research, join projects, or explore, hack and learn technology. Many young entrepreneurs see the potential of these spaces due to its relative cheapness in creating technology. Labs can be attractive for students, graduates or people with business ideas that can use the laboratory for its ease to space, tools, equipment and knowledge repository.

[1] (ScienceNordic, 2015)

That correlates among many things to project or business development with low capital, in return for paying a small membership fee. In the education environment, the labs allow hands-on interaction with the use of technology. It bridges the gap between theoretical and practical knowledge for example in humanities and social sciences. This overall rise of such spaces could be due to individual's natural curiosity that drives the man to exploration, hacking and improving things. Not that long ago, people were used to doing most of the things at home that are happening in living labs such as basic fermentation or adjusting electronics. It becomes a trend to do these little experiments again. That is one of the motives to investigate what is the impulse that drives people to form themselves in such spaces. It will be important to seek and explore the hype, the phenomenon of the living laboratory.

This thesis will explore what some call the wonder of City Labs/Living Labs. These spaces are emerging sites in the cities and universities, where the group of enthusiasts that share a similar interest in technology forms them. The labs can be public or private entities where some of them are tightened to business industry. It is a new style to invent things, where the myth of single inventor is debunked, where collaborative effort is used to invent things. This type of lab is not new, the notion of the laboratory was introduced already by Edison. Where he accomplished together with his fellows '*muckers*' (as he called them and they called him back the *'Chief Mucker'*) all the new inventions. It is new to traditional R&D laboratories in corporations. This type of labs as spaces is becoming visible, where people can do interesting things with equipment, software, hardware and what not. It is a kind of space where people can interact and meet with each other. There are various communities that interact and meet purely out of mutual interest. However, these kinds of spaces vary by the engagement with the outside world. The mutual interest in something makes them collaborate, co-create and share knowledge among themselves, but the engagement with the outside world is crucial. If we take an example of international network activist and hacktivist called *Anonymous*. There is a certain philosophy that unites them, but it is the public engagement and contribution to outside world that makes them stand out compared to others. The variety of potentially used tools in hacker and makerspaces is wide, from tools such as 3D printers, CNC (computer numerical control) machines and CAD (computer aid design) software.

The term city lab/living lab is an interesting phenomenon, which is emerging in scientific research literature only recently. Thomas Alva Edison was the first to create such a laboratories or *Invention factory* or *research laboratory* as some would call it. He moved to Menlo Park in 1876, where in his laboratory he and his assistants had several projects going on at the same time. They spend together a vast amount of time by inventing and relaxing after working hard. Edison's goal was to make a small invention every ten days and a big invention every six months, eventually, they became successful and Edison was planning to build a bigger laboratory, where they could continue inventing, which he eventually did.[2] The drive for Edison was to invent not to make a profit. Profit was secondary but necessary for him to keep inventing. It is fair to say that Edison's research laboratory was one of the first kinds of living spaces, where work, interest and leisure time integrated. The lab is an example how such a space can outgrow into large R&D facility. Edison's legacy lives on in Silicon Valley. (Walsh, 2010) Silicon Valley gained popularity around the 1980s and it is known for being a home to many of the world's largest high-tech companies and thousands of startups.

Many universities have various types of labs, which are usually established within the framework of particular study department. Students use these kinds of spaces, where they can realize their ideas for projects. Such a space can be seen as a place where knowledge is shared and where ideas become projects. The aim of this thesis is to explore various kinds of spaces, which exists under term *living lab* or *city lab* with a rich diversity of projects and activities. In literature, living lab or city lab can be undergoing by different explanations. There are different views on what living lab constitutes between scholars.

[2] (Agile Writer, 2015)

One of the explanations is that such a space is localized space of collective innovation like makerspaces, hackerspaces, Fab Labs, co-creation spaces, co-working spaces (Capdevila, 2014) or by definition of Westerlund and Leminen (2011) according to whom living labs are:

"Physical regions or virtual realities, or interaction spaces, in which stakeholders form public-private-people partnerships of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts." (Westerlund & Leminen, 2011: 20)

Similar view to see living labs as it was in the example of Edison's lab holds Ballon et al. (2005) living labs are experimental environments where stakeholders form multiparty partnerships to prototype, create, validate, and test new products, services, and technologies. Kusiak (2007) sees living labs as physical or virtual regions, where technologies, services, and products are being developed and tested, and user's involvement is as informants and co-creators of innovation. Lindtner et al. (2014) define hackerspaces as *"shared spaces that bring together people engaged in building creative technical projects through the sharing of equipment, tools, software, and hardware."* (Lindtner, Hertz, & Dourish, 2014: 340)

It offers a range of deep engagement and critical reflectiveness towards technological design contrast to media and governments who live on the eager hype. (Lindtner, Hertz, & Dourish, 2014) In Lindtner et al. (2014) example is interesting the contrast between the engagement of hackerspace's members on one side and government on the other side using this hype to profit and refresh the economy. And lastly according to Leminen et al. (2012) living labs are meant as *"reconstructing the interaction space. It can be any space, anywhere, suitable for collaborative design, the application of knowledge for empowerment, uplift, and development of people and communities for the use of information."* (Leminen, Westerlund, & Nyström, 2012: 6)

Therefore, one of the aims of this thesis will be to explore living lab and the dimensions that constitute it. With Edison, university labs and hackerspaces as inspiration to and background for what labs can become this thesis will explore what some call the wonder of City Labs/Living Labs. This thesis will draw from case studies, where the data and information were collected in ethnographic fieldwork of two different facilities.

The reason that drives the decision to perform fieldwork in two different facilities/laboratories is to bring a diversity of what living lab can be to the research. In the past six months, I have visited distinct laboratories and spaces with wide, diverse focus and interest, participated in daily activities and events and assisted in specific technology development.

1.1. Research question

1) How do living labs work with tensions between their ideals of engagement, openness to information and at the same time mobilizing resources to 'pay the rent' and invest in necessary technology they seek?

2) How objects in the living labs are formed, and how they are enacted in different situations/practices that can be located in different spatialities?

2. Living Lab ontology I

2.1. Living Lab/City Lab explored through databases

In this Master thesis, I will engage in two cases of living laboratories that go under various names as *living labs* and in some literature (Capdevila, 2014) as *city labs*. One way of interpreting the word *living* in collocation living laboratories is to describe it as an organism where the events are in constant transformation, shaping and formation. Living Labs is a notable topic in user and open innovation. At the end of this section will be presented a set of dimensions that are derived from challenges and tensions in literature review and which will be used in *Analysis I* section.

In an exploration of available literature about living labs/city labs were chosen two databases (Scopus and Web Of Science) of peer-reviewed literature such as scientific journals, books and conference proceedings. However given the result only Scopus database was used, because it offers an option to analyze search results. Scopus database contained more literature and allowed to display available literature on the timeline, which was used to look at as a trend line. These are the keywords that were chosen: *living labs, living laboratories, city labs, and city laboratories.* Data range was all available years to 2015 with all type of documents.

As it is seen in *Figure 1* the available literature on living labs emerges only recently in the scientific literature. Which corresponds with the different opinions about what constitutes a living laboratory from the scholars as mentioned in the introduction. The result from Scopus offers other ways to explore and analyze search results e.g. according to country/territory or subject area. The results can be filtered out for the appropriate subject area, document type, author's name to the specific keyword that supposes to be covered.

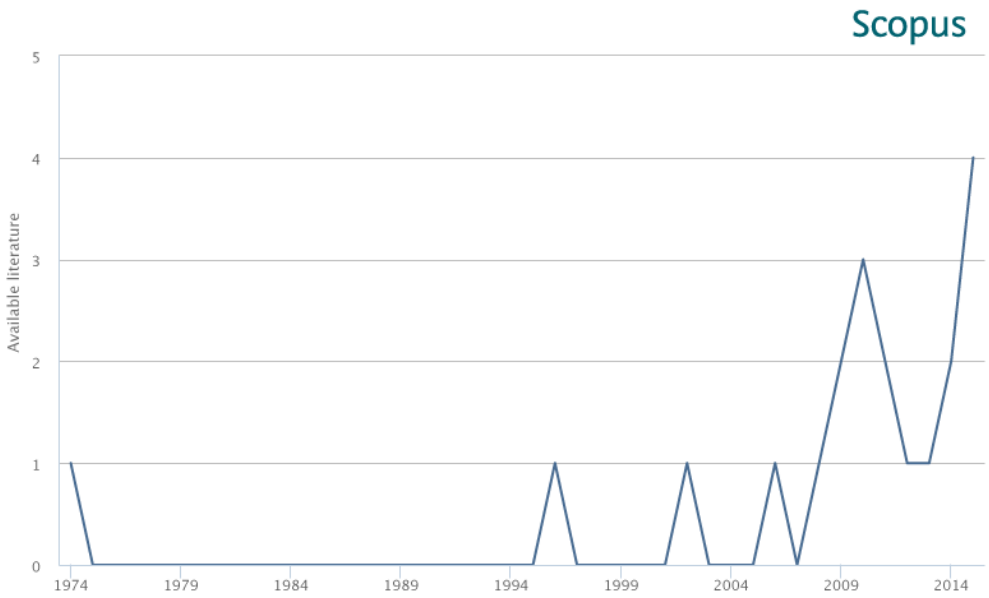
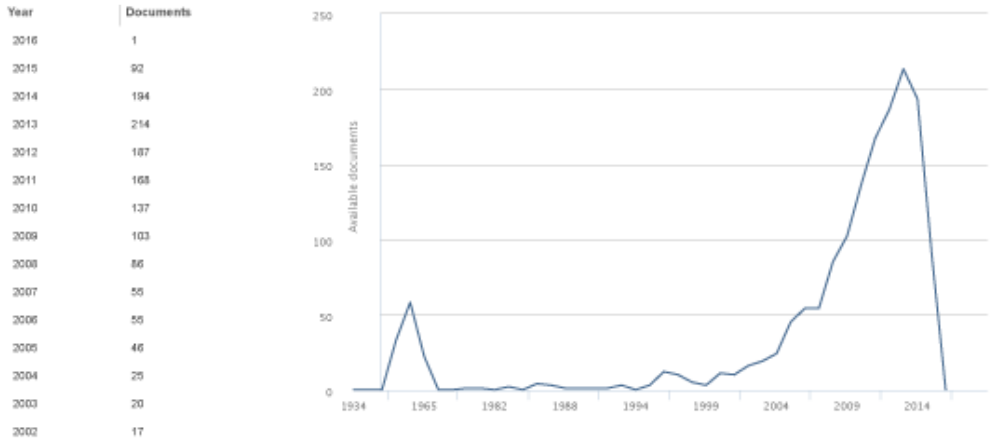


Figure 1. Available documents on living labs from Scopus with keywords: living labs/laboratories and city labs/laboratories[3]

On the *Figure 2* are available documents with wider time range where is shown how many documents are affiliated with the search term in given year. Years that contain most documents on given searched keyword are 2012, 2013, and 2014.



Year	Documents
2016	1
2015	92
2014	194
2013	214
2012	187
2011	168
2010	137
2009	103
2008	86
2007	55
2006	55
2005	46
2004	25
2003	20
2002	17

Figure 2. Available documents with keyword of living labs from 1934-2015[4]

[3] (Scopus, 2015)
[4] (Scopus, 2015)

Scopus results can be downloaded as the .csv file that can be further uploaded on the web ScienceScape[5], which is a tool created by Médialab, where the results can be further explored and visualized in a number of ways.

The phenomenon of the living laboratory is not recent as pointed out in Edison's lab example. However, the given literature results shows rather a small-scale number of scientific literature devoted to this phenomena. One of the reasons could be the diversity of titles this phenomenon is given and used in various fields. There is a missing unifying term that would be used cross-disciplinary in different fields while the term city labs/living labs is used in association with different fields of study such as computer science, medicine, engineering, biochemistry and social sciences where it may be used to have different meanings.

The most occurred collocation in explored data from Scopus was keyword *living lab* with red color in *Figure 3*., which could be affected by the search term. However it showed connection to other articles and keywords. Second most keyword with green color was collocation *living labs*, third keyword with turquoise color was *smart cities*, and fourth most cited keyword with purple color was *open innovation*. Around these keywords was formed a network with less frequent keywords that helps to explore the phenomena.

[5] (ScienceScape, 2015)

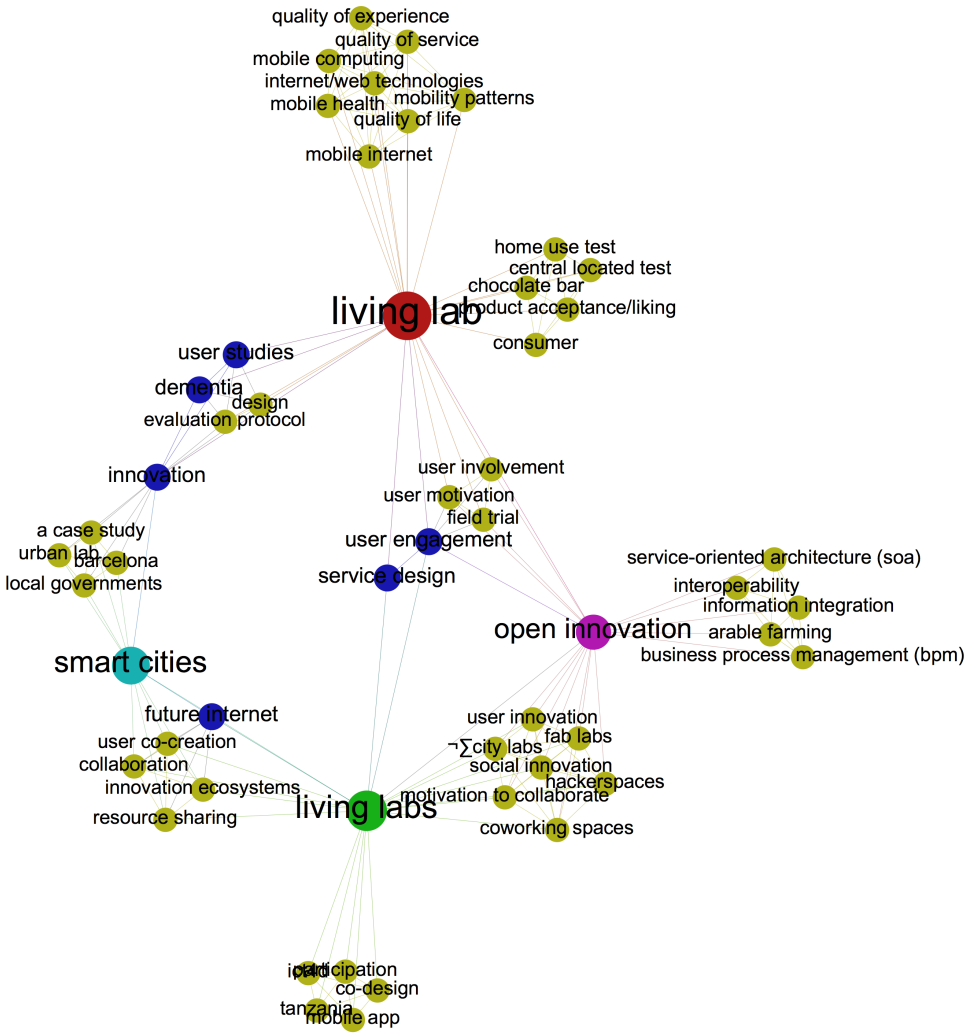


Figure 3. Keywords of authors' articles at Scopus

As shown the trend line of emerging living labs and city labs in literature takes place only recently. The prediction would be that the number would get higher as more and more researchers will conduct their fieldwork in such a spaces. To confirm the validity of statement derived from Scopus search that living lab/city lab lacks number of documents written about it to this date according to (McPhee, Westerlund, & Leminen, 2012) there is not abundant amount literature on this topic. One of the reasons could be that the concept of living labs is still relatively new and to apply traditional experiments to such an environment could be challenging. According to (Almirall, Lee, & Wareham, 2012) experiments have been realized in laboratory-like setting, which possess more control of environment for data gathering. Compare to recent practices, which favor a real-life environment that causes loss of control.

Leminen et al. (2012) estimate that the concept of living labs (or living laboratories) emerged in the early 1990s, which is approximately the same time as hacker and makerspaces being mentioned further in the introduction part.

2.2. Living Lab phenomenon

How can we characterize a living lab? For the reason that the term *living lab* is broad, it will be necessary to go through literature to find out what are in my opinion the critical dimensions. Some scholars define living lab as a term of user communities whose practices have been used by high-tech companies to validate the new technology. (Mulder, 2012) In her article, she draws from three cases in the Netherland that used *living labbing* to enable citizens to co-develop their city. She concludes that living labs do not benefit from their potential and that the living part makes a living laboratory an exceptional methodology for user-driven and co-creative innovation. Although her focus in the study is more on the methodologies that are used in living labs in her conclusion, she points out that tools and methods used in living labs are heterogeneous and may differ among living lab sites. (Mulder, 2012)

This thesis investigates more than one living laboratory, where distinct spaces were chosen intentionally to explore the use of tools in practices. Further, it will be explored the ideal of access of lab towards public, whether lab's aim is to be open to anyone, whether the access is restricted in a way or the aim is to be more elitist. As it will be introduced later on, living labs possess the knowledge sharing towards the public, which will be explored in a similar way as access to these facilities. Another aspect that will take part in the fieldwork to help to define the purpose of particular space is the level of commercial involvement. The aim will be to find out to what level space is or isn't an ambitious startup with the application of living lab ethos that can be seen in hacker and makerspace community. The newness of the term allows different scholars use it in varying fields from art, biology to institutions, corporations, and many others, where divergent stakeholders are involved. The need of definition between where space behaves as an open pool of knowledge that allows its members to gain and share knowledge and when space becomes commercialized is required. It is a critical question whether we can still call it a living lab when the notion of commercialization is involved. It is disputable, and I will come back to that below in my empirical analysis.

To navigate among various spaces Leminen et al. (2012) suggest categorization of city labs that can be differentiated into four categories as providers, users, utilizers, and enablers. Their typology is based on interviews with participants in 26 living labs in Sweden, Finland, Spain and South Africa. They refer to living labs practices as open innovation networks and to better grasp how living laboratories work; they suggest categorization. Openness associated with these kinds of spaces where a design of devices, machines, and physical things is being used, modified and distributed so anyone can have access to those things. This categorization will be used to help to define labs in the *Analysis I*. It helps to differentiate labs based on their approach. Laboratories offer social and technological resources that allow people to collaborate on the production of new technologies, by sharing tools, software, hardware, and equipment. (Lindtner, Hertz, & Dourish, 2014) These resources have a different origin, but if we take into consideration hacker/maker and biohacking spaces the members provide them usually itself. Categorization model suggested by Leminen et al. (2012) and built on by (Capdevila, 2014) helps to navigate in living laboratories and their differentiation based on which actor drives their activities. I will apply this model in analysis section on two case studies. The argument for the importance of categorization use is to find whether two case studies fit in such model. The reason is to test this kind of model. The types of living labs are in four main groups, utilizer-driven, enabler-driven, provider-driven, and user-driven. Each group is divided based on their characteristic, purpose, organization, action, outcomes and lifespan. Utilizer-driven living labs have short lifespan they are usually used for fast results that can be implemented in business models with information collected from the users. The outcomes are new knowledge for products and business development. Enabler-driven living labs represent places such municipalities and towns. They are usually formed around a region or funded projects and aim at developing a specific regions or city areas. Their lifespan varies from short to long-lived. Provider-driven living labs are universities, educational institutes or consultants. The aim of this type of lab is to promote theory and research development, knowledge creation and coming up with a solution to particular problems. They form around a provider organization, such as university with short or long lifespan.

User communities that are a specific community of interest such as hobby group create user-driven living labs. They cannot be managed because of its bottom-up principle. Their outcomes are solutions to users' everyday life problems with a long lifespan. (Leminen, Westerlund, & Nyström, 2012) This model will work as initial criteria for observation in two cases. Some of the limitations as *the organization and leadership in living labs may change over time* and that the model *should not be taken as a definite guideline* pointed out by Leminen et al. (2012) will be taken into consideration.
According to Wenger (1998), collaboration in some of the living labs may cause a formation of communities. Communities play very important part in user innovation, and they are responsible for the acceleration of the development and at the same time experimentation of novelties. They are also autonomous, emergent where the knowledge is shared openly. Emergent user communities tend to be more hesitant or unwilling to management control (Wenger, 1998). Such communities distinct themselves with the properties that stimulate growth, development or change in traditional corporate research and development (R&D) departments, where nature is to keep internally new knowledge and innovation (Capdevila, 2014). Communities' members take part in the development and testing of innovations through a frequentative procedure of products experimentation. Such communities are closely related to practice, and can be regarded as similar to the communities of practices (Brown & Duguid, 2000; Wenger, 1998)

According to Anderson (2012), there is access to these facilities/labs and the availability of the equipment. It poses certain artistic and expressive promise, and some are not afraid to call it *The New Industrial Revolution* (Anderson, 2012). Some literature as Anderson (2012) praises this new movement, but there is a potential to shift into the form of consumer culture. Where could I raise questions such as does the world need more stuff? Is it only an elite group of users printing more junk or there is actual potential for the exploration of its devices and software? These issues will try to cover dimension of sustainability and ideal of access in the *Analysis I.*

Hacker and makerspaces have been around for some time and only recently become more popularized. Hacker culture goes back to 1960/70s where members were designing technologies whose purpose was to be open and modifiable.

Many products we have nowadays are due to the alternative model that goes under various names as *open-source* or *peer production*. The typical hackerspace is equipped with 3D printers; laser cutters, Arduino components, and computing tools that let one explore the physical and digital boundary. (Lindtner, Hertz, & Dourish, 2014)
Lindtner et al. (2014) perceive hackerspaces as drivers of economic and societal change and portray them emerging in several waves build on (Maxigas, 2012). The first wave was mentioned in the 1990s where the access was limited to few. The second wave in Berlin, Germany was significant by its public profile and Internet freedom. The third wave was dedicated to global hackerspace movement and the fourth wave added by Lindtner et al. (2014), where hackerspaces are perceived as *"incubation of startups and as functioning in the realm of research and development."* (Lindtner, Hertz, & Dourish, 2014: 444)

One of the first hackerspaces in Europe was C-base, which was opened in 1995, currently there are around 1900-2000 hackerspaces listed on the hackerspace wiki page from which approx. 1250 are active, where people are allowed to network freely and exchange experiences and ideas. For example in China, they try to distance themselves from the word *hacker*, in Chinese *heike*, due to an event in 2010 where the certain group of hackers broke into Google's servers. Instead of using terms containing word *hack*, *hacker,* etc., the term *creative professional* is used instead. (Lindtner, Hertz, & Dourish, 2014)
Lindtner et al. (2014) show the difference based on their data obtained from interviews. Hackerspace in their terms was innovative compared to traditional R&D labs, where the progress is slow and absorbed in patent wars. One of the applications of using various hacker and maker spaces can be seen in the example of government initiative in Shanghai (Lindtner et al., 2014), where this kind of spaces are endorsed and supported by the government to change China's economy from copying products and manufacturing for others to creativity and innovation. In the US, it is bind to economic recovery to bring back *made in America*.

The vast variety of labs mentioned in the literature was the impulse to conduct fieldwork in more than one lab. These labs have different approaches, focus, and use of technologies, software, and attitude to members. For those reason dimensions of the purpose, reality of resources and freedom will try to cover this area in living labs.

2.3. Living Labs as a startup success

In most of the hacker and makerspaces nowadays can be found a 3D printer. Almost every place has one, which is usually built by the members that love to explore and play with what 3D, software or BIO can do. When it first came out the hype around 3D printer was enormous. Open source hardware whose design was made publicly available so that anyone could study, modify, distribute, make and sell the design created. Everyone was talking about the revolution; it supposed to revolutionize the way we do almost everything. Comparisons were drawn to Apple and Steve Jobs. It was a story of a group of enthusiasts that created a 3D printer in the scale that could be used on the table. The predictions proclaimed that anything could be printed from clothes to human organs. One of the founders Anthony Moschell's wishes was for the information to stay open, so the people can have access to it forever. There were also other companies, but MakerBot was the one the most talked about with its website where people could freely share files of 3D objects that could be downloaded and send to print in seconds. However with this new technology came a controversy. The person is representing information anarchists, who do not distinguish between public or private information, came up with an unintended use of this technology, to print a gun. It became a controversy that cast a shadow on this new technology that everyone was praising. Such thing can force the company to close the openness for the other in terms not to be misused.

"For me, personally, I look at a move to closed source as the ultimate betrayal." – Zach Smith co-founder of MakerBot (Pettis, Lobovsky, Reichental, & Wilson, 2014)

Some obstacles that a new technology can face are the need of media to feed on controversy and lack of this technology's definition on the market.
Nevertheless, it became also a competition for big corporations and besides some people in MakerBot changed their attitude, when they happen to make more profit. (Pettis, Lobovsky, Reichental, & Wilson, 2014)

From the ethnographic study by Lindtner et al. (2014) in China, the attitude with living labs is to establish a new take on Silicon Valley tech production. The program manager of 15-week-long program believes that what was formed before by only a few professionals is now available to masses. The openness that pervades in hacker and makerspaces contrast to what the program manager claims. Whenever there is a product or project without a potential turning into a product, it gets filtrated. The commercial effort of doing business and creating products diminishes and impede the freedom. Freedom to information that is one of the foundation stone of hacker and makerspaces and uses it to turn it into business. (Levy, 2010)

The hacker ethic claims to have an *"access to computers – and anything that might teach you something about the way the world works – should be unlimited and total."* (Levy 2010: 53) *"All information should be free."* (Levy, 2010: 54)

According to hacker's ethic to support the free exchange of information is to have an open system, where should not be any boundaries between a hacker and the information. Bureaucracy cannot contain the exploratory impulse of hackers because it is a flawed system hiding behind arbitrary rules consolidating powers perceiving hackers as a threat. (Levy, 2010)

2.4. Consideration of sustainable technology innovation in living laboratory

As Brynjolfsson and McAfee (2012) would say, we are on the verge of new industrial revolution, which is fueled by computers and networks. They claim that organizations and our skills do not progress at the same speed as the rapid change of digital technologies. As a consequence millions of people are left behind in a less advantageous position, with their jobs and incomes being destroyed, where they are worse off even than before the digital revolution. Their stance is although towards this *race against the machine* not pessimistic for the reason that technology accelerates the new territory discovery and will continue in doing so.

Some scholars as historians Basalla (1988) would be more skeptical towards innovation. He brings up to discussion sustainability issue, where he is concerned with addiction to technology and its impact on society. He would have a different view on the evolution of technology. In his opinion we have become addicted to our technology, we are trapped, and we cannot survive without it. If we just eliminated electricity from our lives, many would perish. He says that many famous inventions were not original or unique that no one ever thought before. They were part of the evolution. The mother of invention was evolution, not revolution. We live in the illusion that the golden age, the age of leisure is yet to come, but the ideas and illusions block the path to sustainability. What we could take from his book is that way of living with endless progress is not sustainable. Maybe we should think about other actors involved in the chain and prioritize the needs of humans differently. To relate this issue to living labs, the dimension of sustainability will be taken into consideration as one of the factors. Observe to what degree living labs are a concern with the impact they have on the environment.

On one side there is a big open pool of knowledge, which people can use and cherish from, which is an ideal of access that is aimed for in some labs. The accessibility of tools such Arduino components are at ease to build up quick prototypes, but it is a question how do they finance this equipment. The 3D printers are ready to print anything from prototype components to a replica of sculpture in small scale. All different kind of wires, cables, pieces of hardware, broken toys, hard drives, used plastic tubes, and gloves are laying around and are produced or used in hackerspaces and bio labs.

3D printer uses PVC (Polyvinyl chloride) to print the 3D objects. By looking at the pile of prints in the bucket, where most of them are printed objects, where some ended successfully and some did not, it raises a question what to do with all this 'waste', which haven't found its purpose or usage? What are the environmental impacts of these machines?

Another aspect of bringing into consideration is what is being done to extend access beyond a privileged group of tinkerers? This is one of the aspects to focus in fieldwork, whether the group of members related to a particular place is inclined to share knowledge, tools and space with others or they intend for elitism. On the other hand, the inventiveness and creativity that these spaces suppose to possess are taking notice by firms and companies that try to take advantage from.

Based on the literature review above is formed a set of dimensions that will be closely observed in the practice and analyzed in *Analysis I* section. Some of the dimensions listed below, in my opinion, are not explored enough in depth in the literature. For that reason, they will be explored in the practices.

1. The first dimension is the potential level and the aim of particular space of becoming commercially successful (purpose).
2. The second dimension focuses on how each lab is regulated. (Self-regulation)
3. Third dimension is the reality of resources, where is taken a closer look at funding and payments (such as rent).
4. In the fourth dimension is observed the ideal of access, to what degree space is open to public and private entities.
5. The fifth dimension will explore the level of freedom in each space.
6. The sixth dimension will observe the level of sustainability involved in the ontology of lab.
7. The seventh dimension is the definition of living lab by the members.
8. The eighth dimension is the categorization by Leminen et al. (2011) to what category given laboratory comes under.

2.5. Techno-anthropologist in the laboratory

What we do as techno-anthropologists is that we deal with various logics that affect or support human abilities and capabilities, which are arbitrated by technology. (Børsen & Botin, 2013) Technology is continuously re-shaped and re-configured with how it is used, misused or abused. It creates new needs and demonstrates the ongoing interaction among humans, culture, and artifacts. It gives us visions of the future. Technology shapes what means to be a human. (Børsen & Botin, 2013) In this sense, it is very important that we participate in technology development without leaving it behind closed doors of laboratories. Its appliance can be consequential to humanity.

Laboratory is a place to conduct creative research, where the focus shifted from studies such as philosophy, humanities, social studies and many others. Just to mention scholars that are cited in this thesis, Bruno Latour *Laboratory Life* (Latour & Woolgar, 1979) and Annemarie Mol *Ontology in Medical Practice* (Mol, 2002) were one of those. Before conducting the study in any laboratory without previous knowledge might be seen as an advantage. Bruno Latour is such an example with *Laboratory Life* in Salk Institute. At the time, he was a philosopher interested in science without knowledge in anthropology or sociology.

"Professor Latour's knowledge of science was non-existent; his mastery of English was very poor; and he was completely unaware of the existence of the social studies of science." (Schmidgen, 2014)

As Arne Naess (1936) said, the action of scientists should be observed as though by a *researcher from a different galaxy*. Consequently, there is no experience of understanding needed when doing ethnography, in other words, it is an advantage.

In a similar way, I will in this thesis try to go out and visit the labs, participate in what they do to explore the set of dimension and after that describe what I saw. Therefore, the importance is to seek to explore the hype, the phenomenon of living labs. To investigate, what is the impulse that drives people to form themselves in such spaces.

As mentioned above the characteristic of living lab is broad and, therefore, it will be aimed for the definition of each living lab. For that reason, I will conduct my study in two spaces to unveil the phenomena of the living lab that will be chosen based on following criteria. It has to be localized or the virtual place with collaborative effort and sharing value that nature is being experimental where members engage in activities to reflect on technology.

This *Living Lab ontology I* section's literature review will be summed up with dimensions that will be explored and used in *Analysis I*. First will take place the introduction of each laboratory and their ontology, where will be explained how they were created and what is their main aim and purpose. It will be explained how they self-regulate themselves to understand how they function, what rules they have and what their meeting etiquette is. Next step in defining the living lab will be to investigate the reality of resources to see how they pay rent, get funding, equipment and tools. As another dimension will be explored the ideal of access to space by public. How much are they open to new members and what is their relation with public etc. Last two dimensions will be the level of freedom and sustainability to see what level of freedom each space offers to its members regarding exploration, research, and management with the attitude towards sustainability issues. Based on the collected data and analyses of each lab they will be categorized by Leminen et al. (2012) categorization and definition of particular living lab will be done. At the end of *Analysis I* all labs will be summed up based on their dimensions in a table to be able to see differences. This section's aim was to create a narrative for living laboratories from available literature that was combined and compared together to present the past and current discourses of living labs.

3. Living Lab ontology II

3.1. Ontology of objects and subjects in living laboratories

In the *Living Lab ontology II* will be introduced the theoretically informed ethnography framework, which will be used in *Analysis II*. At first, will be introduced the ontology of objects and subjects relation in living laboratories practices that are enacted in multiple different realities that is shown by Annemarie Mol (2002) on the example from her ethnography. In *Spatialities* section will be introduced how to gain embedded knowledge in the laboratory that is imbedded in nonverbal patterns, procedures, and instruments. How different things come into being when knowledge is investigated in daily events and activities. And four different spatialities (region, network, fluid, and fire) will be introduced where object/knowledge can be located. In *Multiplicity* section will be introduced how to understand reality as an enactment, which is multiple due to practice distinctiveness where objects are handled. And in *Partial connection* are described networks that are held together by forces and those forces are associations, which bring new possibilities between humans, society, science, and technology. Partial connection as research methodology brings more means for research and to practices. The aim of this section is to explain the ontology that will be applied in the *Analysis II*.

One of the aims will be to define the essence of living lab or, at least, come close to defining it. It is arguable whether we can define ontology of living lab from two case studies; nevertheless, it will be an attempt and contribution to living lab studies. According to Mol (2002), *"ontology is not given in the order of things…instead, ontologies are brought into being, sustained, or allowed to wither away in common, day-to-day, socio-material practices."* (Mol, 2002: 6)

The involvement in daily activities is crucial, for to grasp leastwise a bit of what is the ontology of living lab. Mol presents in her study that such everyday reality can be multiplied. She shows a multiplicity of the reality on the example from her ethnography in the hospital.

"I went to see my general practitioner. She sent me in to the hospital. And now I've got two diseases. I've got atherosclerosis, they tell me, and diabetes. I've also got diabetes." (Mol 2002: 8)

The way we can see the world can be made up out of different perspectives of how we perceive the truth. Mol is against different perspectives that make truth. Instead of using perspectivism, she uses enactment. Perspectivism's knowledge resides only in the subject and its singularity of out-thereness. Meaning that the world is a single thing, and there are definite and limited, a single set of processes. (Mol, 2002) For Latour and Woolgar (1979) in *Laboratory Life*, there was one single reality, but only after controversies have been resolved, and statements become fixed. Before the reality was unknown and also multiple. (Law, 2004) Latour and Woolgar tried to escape from a place where reality supposed to have permanent attributes. Every time a statement was stabilized, it was reintroduced to the laboratory under varying nature (inscription device, program, machine, etc.) where it was used to enlarge the disparity between statements.

Inscription device is *"a set of arrangements for labeling, naming and counting. It is a set of arrangements for converting relations from non-trace-like to trace-like form. It is a set of practices for shifting material modalities."* (Law, 2004: 29)

Therefore before studying the laboratory environment, the reality may seem multiple; there may be many actors involved in the practice that should be taken into consideration. It helps me to think about and prepare for the research before doing it. Latour's inscription device that Mol and Law (2001) enriched by other spatialities will be used as an inspiration in the *Analysis II*. When we dive into the field of study, we might find even more actors that change their form, which can be mutable or immutable and mobile or immobile.

3.2. Spatialities and embedded knowledge

To gain embedded knowledge in the lab it is necessary to focus in the fieldwork not only on subjects, but take into account objects, structures, culture or as Mol (2002) describes embedded knowledge as something that cannot be concluded from people's conversation, but as something that is imbedded in nonverbal patterns, procedures and instruments. Further, she describes the knowledge being integrated with practices, not solely in subjects, but also in objects. She describes atherosclerosis as an event where is need of divergent knowledge, actors, and human and nonhuman objects from many disciplines. People and other things that are involved bring this event and many others into being. Things such as words, rooms, buildings, paperwork, software, and materials. (Mol, 2002)

In the similar way as Annemarie Mol does it in *Body Multiple* the actors in the living lab will shape their reality. Our daily life includes all sort of actors as Mol puts it, *"Day-to-day reality, the life we live, is also a fleshy affair."* (Mol, 2002: 27)

Mol refers to, how doctors and patients give a shape to reality by patients hurting legs.

"A matter of chairs and tables, food and air, machines and blood. Of bodies." (Mol, 2002: 27)

Feelings and interpretations are not left alone in making what the life is about. She suggests talking about these issues freely without leaving them behind closed doors of professionals and find new ways to talk about them.

Latour (1993) addresses many things in his book '*We have never been modern*'. He breaks down the distinctions between subject and object, mind and body, language and fact, etc. He distinguishes between *subject* and *object*, where the subject is social and vigorously knows, and the object is natural and being known. His intention is to escape from subject and object separation. Similarly, as Mol (2002) he further claims that subject and object are two poles of the spectrum and, therefore, creates a mixture, which we have to learn to realize.

Mol (2002) summarize his book by noting that instead of jumping between subjective mindset and objective reality we would better do if we accept that our practices are *"thick, fleshy, and warm…made out of metal, glass and numbers"* which are continuously uncertain. Similarly, as this thesis Mol (2002) uses this to explain her field study in the hospital, where she investigates knowledge in daily events and activities instead of knowledge being expressed in words and images printed on paper. The knowledge is located in instruments, buildings, events, and activities and so on instead of being in subjects' mind. Therefore, the knowledge is located in objects as Latour (1996) suggested in *On Interobjectivity*. He asked *what do symbols hold onto*, to which he answered *objects*. He suggested incorporating objects beyond subject into a science of social.

"We must consider objects as determinant for the social world." (Latour, 1996: 235)

He further proposed that by drawing boundaries we make sense of interaction, it helps to reduce the complexity of social interactions. Therefore, boundary objects may consequently be seen as the glue that holds inter-objective with each other.
John Law and Annemarie Mol (2001) write that something has changed in the understanding of the sciences, they give a brief statement that facts have been localized. They distinguish among four spaces in which objects/knowledge can be located: region, network, fluid, and fire. They vary based on their mobility and mutability. They can be mutable or immutable and mobile or immobile based on the space they are located. They emphasize that transport is crucial to find out how scientific findings and theories move. Some of them are regional, they are made somewhere in specific locations (e.g. laboratory). But they move from the laboratory to other laboratories as well, if the arrangement that produced it is reproduced. Latour (1987) has defined a scientific knowledge/object as *immutable mobile* in his *Science in Action*. Immutable mobile is referred to easy transportation of knowledge/objects in techno-scientific networks, where the key characteristics are retained. The concern with transport and immutable mobiles representing knowledge/object lead to the creation of Actor-network theory.

Law and Mol (2001) build on Latour's immutable mobile, and they define it as an object that remains united in a specific web of relations, but at the same time comprise a form of spatiality. As mentioned above, they gave distinction to four different spaces. Regional objects are immutable and immobile as the result that they are located at one place and nowhere else (local presence). Network objects are immutable and mobile as the result to have the potential to circulate while holding their shape. Fire objects are mutable and immobile as the result of the relation between presence and absence: simultaneous absence or alterity. And fluid objects are mutable and mobile as a result of the ability to change shape as they flow.

This contrast among spatialities allows technology to be for instance fluid and move in the network of relations. Such distinction of knowledge/object in spatialities will be used in *Analyses II* of the fieldwork data.

3.3. Multiplicity

Mol (2002) in her chapter on subject and object moves into the direction of gender, where she says that human subject can be studied by exploration of their identities that are performed in different situations and objects in practice are enacted. Subjects and objects, human and natural are arranged as elements of events that appear and action that are staged. While she makes good points with whom we could agree to some extent, yet we are not sure if and to what extent we can say whether gender is enacted or given, *"the body's sexual organs are not enough to mark it."* (Mol, 2002: 38)

There are things that are proven and based on evidence as from the medical point of view the things that we can measure e.g. blood sample on testosterone, what doctor sees on the skin, hears on the lungs are objective. But when we listen to the patient what does it hurt them, how they cough, it is influenced by their perception and processing of the problem in their head. The doctor's objective view is proven by their medical knowledge and open examination of the patient. We cannot say with certainty to what degree the role of gender, how we behave is given and learned. Although it will be bear in mind that some of the actors in the practice have certain roles they play, which are related to the position, role or status they are given.

Mol (2002) builds up on (Armstrong, 1988) where he claims that materials are active engagement in the character of reality and knowledge is not situated in minds. She further explains that through enacting reality (practices), which is kept open, there are varieties that multiply. There is a multiplicity. The reality is multiplied, instead of understanding objects as a central point and things that are manipulated in practices "*objects come into being – and disappear – with the practices in which they are manipulated.*" (Mol, 2002: 5) Due to practice distinctiveness where objects are handled, "*reality multiplies.*" (Mol, 2002: 5) Contrasting to perspectivalism, Mol (1999) in *Ontological politics* explains the reality as an enactment. Reality as multiple depends on intervention and performance. Instead of seeing reality by a diversity of eyes while continuing to exist untouched in the center as it is with perspectivalism, the reality is done and enacted rather than observed. She presents it in the example of anaemia that has, at least, three performances: clinical, statistical, and pathophysiological.

She concludes by stating that there are different versions, performances, and realities that co-exist in the present.

In this section, the reality is described as being multiple, reality as an enactment. The knowledge is not situated in minds, but in practices. Enacting reality are various practices that comprise of different actors. In this sense, the various dimensions are made out of different objects/knowledge that are located in practices. For that reason, the attempt in *Analysis II* will be to locate and describe these objects/knowledge that are part of dimensions in practices, which makes the reality of living laboratories.

3.4. Partial connection as research methodology

This section is trying to explain how the reality of laboratory could be understood in a similar way, which is made out of numerous realities (hinterlands). By using this methodology, we can see the partiality in different practices that produce different realities. Those realities are multiple as mentioned in previous section *Multiplicity*. In this sense, the attempt of this section is to understand the hinterland in the living lab to what multiplicity contributes with deeper distinction to object/knowledge.

An example of association could be drawn to the Pasteur's case that was investigated by (Latour, 1993). In his study of Pasteur he connected disease with the laboratory, what happened in real life also happened in the laboratory. Latour used term France's pasteurization to describe chains of association that form networks. If something spreads outside of laboratory, it is because *"there are actors outside the laboratory who associate themselves with it."* (Mol, 2002: 64) Latour (1987) suggests following the actors and chains of associations, both human and non-human, as they are those by which we will be able to reveal the *"consistency of an alliance by the number of actors that must be brought together to separate it."* (Latour, 1993: 185)

In terms to understand the association's evenness or steadiness, we need to know the actors involved to be able to set it apart. Another word for association could be the network. Networks are open; links inside the network might as well connect to networks outside. There is no distinction between internal and external links; they are all associated with each other.

John Law built upon and moved from Foucault's discourses that he abandoned for its shallow view how the social shapes the material. He said that one is a product of doubt, which led to the creation of networks that are held together by forces that one has to be able to identify, and those forces are associations. Kuhn (1970) gave meaning to the word paradigm. Paradigm helped him to abandon the fragmented world, paradigm meant in his interpretation connectedness. In his time data weren't significant, they were devoid of meaning, which he argued against by stating *"data aren't isolated entities…data float independently in a homogeneous void."* (Mol, 2002: 73)

In the opinion of Latour and Haraway (1987), we are all cyborgs due to our constant concurrent part of chains of associations, where we have a contribution to changing them and ourselves. This partial connection brings us new possibilities in between humans, society, science, and technology. The world is made up of numerous relations between human and non-human actors that are caught up in chains of associations. For Haraway, this portrays the notion of a '*view from nowhere*'.

When we focus in the research on the chains of associations by way of which we carry out the investigation, we are able to see the partiality, but not as a matter of course subjectivity that depends on the approach how researcher and researched are held. (Jensen & Lauritsen, 2005)

Law (2004) mentions some notable social theorists who claim that we are not able to step aside from our view of the world and acquire the view from nowhere. To what Law suggest that we have to get rid off certainty, security, and universalism among other things to rethink our methodological habits. On the other hand, we will gain a wider range of realities. (Law, 2004) For Latour *propositions* include realities, a collective. They are part of a more complex network, which may include other propositions. Law calls it *hinterland*.

"The hinterland produces specific more or less routinized realities and statements about those realities. But this implies that countless other realities are being un-made at the same time – or were never made at all." (Law, 2004: 33)

Hinterland is a quantity of material relations comprising statements about reality. It is a concrete metaphor for absence and presence. Hinterland may include inscription devices (Law, 2004) To what Mol (2002) adds that different practices tend to produce different perspectives and realities.

Mol (2002) introduces partial connections through (Strathern, 1991) and gets to her point of the body being multiple is brought together by partial connections, *more than one, and less than many.* For her, the hospital is an organism that hangs together as a result of paperwork flow from one department to another, *the formulae and pictures that translate numbers and other data back and forth* and so on. She refers to the hospital as an organism that "*clashes and coheres – just like society."* (Mol, 2002: 84)

To be more objective Donna Haraway equates a good research with situated knowledge. According to her, even though humans have among themselves vast differences, we are all similar to each other regarding technological and metaphorical involvement in the world in multiple ways. We have fractured and multiple identities, nobody has one.

When she introduces the term dualism, she does not want us to think about it as distinctions male and female, primitive and non-primitive. Her cyborg overcomes and ignores the dualism. We are all cyborgs. "*One is too few, but two are too many.*" (Haraway, 1987: 33) Haraway insist that humans do not define situations; rather they are assemblages of entities.

Jensen and Lauritzen (2005) claim that qualitative research should be about experimenting to learn what goes on in practice where particular relations produce knowledge. Also, according to them research does not have to be forced into prearranged methodological frame, so to speak suggest interesting questions and coming up with interesting answers. They disagree with Denzin and Lincoln (1998) where the position of qualitative researcher does not have to be everlasting reflexive radicalization. As they say, *"it becomes unnecessary to spend energy on constantly trying to re-situate oneself."* (Jensen & Lauritzen, 2005: 68) They conclude that we need more ways of linking with practices, not theoretical, methodical or reflexive techniques to split, disconnect or divide the existing ones. Partial connection as a research methodology is a way of engagement that brings more means for the researcher and to practices. (Jensen & Lauritzen, 2005)

The purpose of *Living Lab ontology II* is help to understand the hinterland of living laboratory and to locate object/knowledge in the practice (enacting reality), where it can be located in different practices/situations that are multiple. And how object/knowledge can be located in four various spaces.

1. *In Analysis II* will be investigated how objects are formed and how they are enacted in different situations/practices by drawing from participation in technology development of spectrophotometer prototype.
2. The act that will be under study is called absorbance measurement that can be imbedded in different practices that are comprised of various situations.
3. In final part of *Analysis II* will be applied four different spatialities on object/knowledge in living lab.

This section will help to analyze and understand living laboratory in more theoretical perspective. It is complementary with *Analysis I*, which explores divergent dimensions and then *Analysis II* follows to investigate how these dimensions that are comprised of diverse object/knowledge are located in practices.

4. Ethnographic methodology and methods assemblage

4.1. Ethnography

This thesis draws from fieldwork study of laboratory places. One of the two cases is hacker/makerspace named Labitat, which shares space with biohacking space Biologigaragen. The second case is ETHOS Lab at IT University of Copenhagen. In such establishments various interdisciplinary projects are combined, where people with different backgrounds and expertise meet. For instance combining biology, technology and art gain an intriguing interest.

The thesis consists of two analysis sections that complement each other and are derived from the Living Lab ontology I. and II. The phenomenon of city labs/living labs is based on the accessible literature with the aim to cover opportunities and deficits. *Analysis I* explores dimensions presented in the *Living Lab ontology I.* The section *Analysis I* starts with the showcase of some digital methods that were used to study living labs. The data, in this case, were collected from the laboratory's website and social media site, particularly Facebook. It is presented as an example of how living laboratory could be studied without being presented in the field. The scope of data collection isn't substantial part of the *Analysis I* and it is used only to show how using post-demographic methods could enrich fieldwork ethnography. Post-demographic invites new methods in how to study networks, where the interest are not the traditional demographics, but rather interests, tastes, and groups. (Rogers, 2009) Further, in the *Analysis I* will be explored dimensions, which will be summed up at the end of the section. In the *Analysis II*, a substantial part is focused on the development of spectrophotometer prototype. Where the notion of object/knowledge enacting in practices is applied to the case. That will lead to discussion and lastly to the conclusion.

Ethnographic methods are used to study living laboratories. What ethnography does, is that allow us to see a fair degree of the messiness of practice. Firstly the focus is on materiality, the physical space of the laboratory. Describing different sections of the lab and what is their purpose. Then the focus is on the actors involved, people, machines, tools, methods, supplies, papers, and it is observed how they move around. Further, the attention concentrates on the activity (set of acts that people do), events, and things that people are trying to achieve (goals), and the emotions felt and expressed. (Spradley, 1980) This investigation of living laboratories tends to follow a cyclical pattern of research practice. The scope of the study is focused on two cases of lab studies. The ethnographic study has been done in Labitat, a makerspace that shares a space together with Biologigaragen that is a biohacking community, a bio lab. The other case is conducted at ETHOS lab at IT University of Copenhagen that is an experimental space in techno-humanities and organizational service, which explores data and data landscapes in contemporary society. The research cycle is derived from *The Ethnographic Research Cycle* (Spradley, 1980), which started with selection of an ethnographic project that was of interest.

To describe something like a laboratory that has multiplicity, various actors, and messiness involved we have to choose an appropriate methods and theory to describe it. By applying logic to something that is not coherent extends the mess. Some of the methods tell us how we have to see and what we have to do and that ethnography has to change to grasp a networked/fluid world. If we do not follow, we risk coming up with something that does not represent appropriately what it describes. (Law, 2004) Therefore various spatialities will be applied to grasp this networked/fluid world of a laboratory.

Sometimes ethnography demands us to do series of tasks. However, ethnography cannot do everything, although it is sometimes demanded. By choosing ethnography, we can unveil various hidden realities (hinterland) that the others use to make sense out of their world. Ethnography seeks to describe the being of alternative realities to narrate them in their words. In this sense, the aim of this thesis is to describe a laboratory life with the relations that it involves, realities and any system that gives a display to actors.

What ethnography does, is that describing the culture. It lets us understand things from the native point of view and the visions of others, it lets us learn from the people. (Malinowski, 1922) The involvement in the studying environment is of great significance. The process of doing ethnographic research can be messy, and fieldwork is one big learning process, where obstacles have to be overcome as to the collection of data.

In the laboratory is studied what people do, know, the things they make and use, and what people say. By the acquired knowledge, we can interpret experience. For the great part of any culture is composed of tacit knowledge. Therefore, informants in the lab may not talk or express in direct ways. It's up to the researcher to listen cautiously what they say, observe how they behave and investigate artifacts they use. By studying a new laboratory culture, we can obtain a new knowledge, both explicit and tacit through speech, both based on casual comments or interviews. (Spradley, 1980)

Before the step of asking ethnographic questions, exploration of various spaces took place. The selection of places was based on the level of possible future involvement in daily activities and events, the possible outcome to enrich significance of scientific work by exploration this specific phenomenon, to investigate hype about phenomena of living labs, and lastly personal interest. The exploration has later on developed in the attempt to map available living laboratories in Denmark. To achieve this, some of the digital methods and tools were used for exploration to discover more laboratories that are in some way connected to labs where fieldwork was conducted.

Ethnography starts with different assumptions. In the ethnographic fieldwork, it has started with broader questions such as *'What is the living lab to you?'* and further in interviews, the focus moved towards more structural and contrast questions.

Participation allowed experiencing activities directly to get an idea what the events and activities are like so the perception could be documented. Following ethnography, it is difficult to become a complete participant in a social situation. In ETHOS Lab to become a participant was through being a volunteer and part of the team in the lab and in Labitat & Biologigaragen it was through being a member and participant in a number of events and activities. And lastly, involvement in developing a prototype in Labitat with the aim to be commercially successful.

The experience was strengthened and elaborated by choosing numerous unknown and unfamiliar situations. Without knowing the tacit rules of behavior, the feeling as a stranger helped to blend into the role of participant observer. Two motives in fieldwork were in focus by facing a new social situation, to participate in activities and to observe those activities, people and physical aspects involved in the social situation. One of the crucial things was to become explicitly aware of the things that would be naturally blocked. (E.g. How people use the space to situate themselves?)

As an insider, this could be experienced through social situations inside the lab. As an outsider, the situation could have been seen as an object. However as it is later argued, we can be both insiders and outsiders by seeing the environment as an organism (Mol, 2002).

In the collection of ethnographic data, the focus was on the activities of people, the physical characteristics of the social situation, and describing how it feels to be part of the situation. The aim was to get an overview about the situation what is happening in living labs by doing broad descriptive observation. This type of observation took place during the whole process of field study, even when the observations are more focused and selective, broad observation allows taking a step back.

Several ethnographic records were used such as taking photographs, field notes, and other resources to record the observations were made during the whole process of fieldwork. These records enable to connect the observations and analysis. All the field notes were kept in a diary, which was scribbled down. The diary contained various kinds of quotes, half complete sentences, words, references, drawings, ideas and so forth.

The records and field notes were usually made while being in the social situation or later when the situation was left. When some situation was encountered that had some interest, from casual conversations when talking to people in the lab or while working on some specific tasks, quick notes were scribbled down. There were different degrees of involvement with people and in the activities that were observed. (Spradley, 1980)

As Becker (1998) says:

"We not only don't know where to look for the interesting stuff, we also don't know what doesn't need extensive investigation and proof." (Becker, 1998: 36)

One thing that he suggests to solve this is to pay attention to something that seems bizarre or unintelligible. It should alert us because we don't know likely about the behavior under study and we should look for to make sense out of it. (Becker, 1998) In other words, we ought to follow the actors.

During the fieldwork, the level of participation was changeable. Sometimes the presence at the scene was like a passive participator, where there would be no interaction with the people and the focus would be solely on records. These different types of participation influenced the data that were obtained. However, it would happen only in Labitat & Biologigaragen where there would be no need in the beginning to interact with people. Eventually, it would not last too long before knowing people around thus the involvement would change to moderate participator. Most of the time in the fieldwork the role would be as an active or complete participant. However, there was awareness of matter when one knows more about the situation as an ordinary participant, the more risk it brings to study the situation as an ethnographer. The less we are familiar with the situation, the more we see. But that can bring into play some confusion as well.

Analysis of data started after sufficient amount of data was collected. The rough analysis of field notes happened after every one or two weeks to discover new questions, approaches to the field and aim what will be the focus in upcoming weeks in the research.

4.2. Analysis of data

The search for patterns in collected data took place in analysis, and it was the most time consuming right next to data collection. To describe the ethnographic research was used a funnel metaphor. At first, the research started with a broad investigation of the available literature to create a narrative for living laboratories. In this phase, various literature on living labs was combined and compared together to present the past and current discourses of living labs.

This study employed a qualitative research approach in analyzing two living labs. The cases were selected based on following criteria: the place has to be localized or virtual space with either collective, collaborative or co-creation effort. It has to be to some extend experimental environment where engagement and critical reflectiveness towards technological design takes place. And lastly space with sharing ontology. Where tools, software, equipment or hardware is shared.

The data was collected during three months, including eight interviews, numerous conversational interviews, conversations, and involvement, in particular technology development. The interviews had structured or semi-structured nature. In semi-structured (focused) interviews the questions were open-ended, broad questions based on the topic areas. It worked in favor to achieve freedom to probe the interviewee to elaborate on a number of areas that supposed to be addressed. E-mail interviews were used as well to get some additional answers from the interviewee. The purpose of interviews was to increase understanding about living labs. The focus in interviews was focused on the set of dimension. Interviews were conducted face-to-face discussion and lasted on average between 45-60 minutes. Main data informants were members of the living labs. Members differ from the ones that have been in the lab longest to shortest times. At Ethos lab, the interviews were conducted with the Lab Manager, two Lab Assistants, and one volunteer. At Labitat and Biologigaragen, the interviews were carried with board members, ordinary members, and newly established members as seen in *Table 1*. The interviews cover themes as background information (steps to make lab running), phenomena and hype of living labs, conflicts in the lab, the level of seriousness, organizing the living lab and so forth.

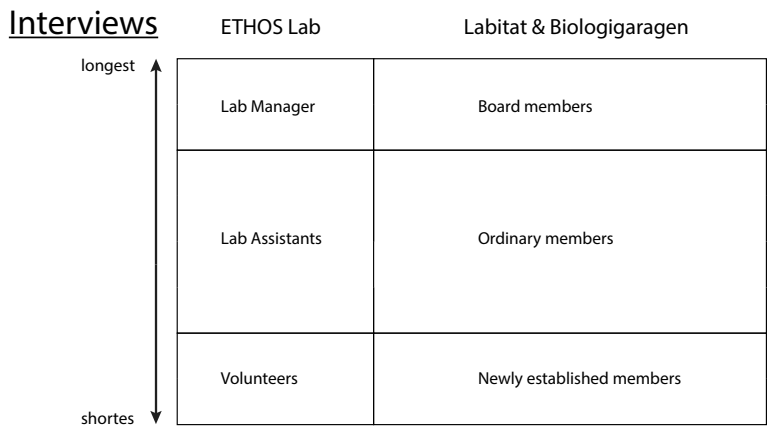


Table 1. Interviews at ETHOS Lab and Labitat & Biologigaragen

As a secondary data were used websites and case studies reports. The data were arranged according to living lab, date as a form of a diary, particular events, and activities, and date of the interviews with a name of the informant that are available in the *Appendices*.

5. Analysis of Living Labs in Copenhagen

5.1. Analysis I

The *Analysis I* consists of two parts. In first part will be introduced the results of the exploration of using some of the digital methods. The aim was to create a network of adjacent living labs that are connected to the two cases that are studied. The result creates an overview of living labs, in particular, the network that offers the possibility for further exploration as seen in *Figure 4-6*. Further, the focus was on the social media, in particular, Facebook, to explore the activity in the virtual reality of each living lab case. The result from social media shows *Figure 7-9*, where is visualized a Facebook page network based on the type of post from Labitat and ETHOS Lab. Facebook's page of Biologigaragen did not contain enough data and therefore was not included. The results from social medias are used for exploration of labs' activities. In the second part of *Analysis I* will be introduced individual laboratories that will be analyzed based on the set of dimensions. In the end, the labs' dimensions will be presented in *Table 3*.

5.1.1. Exploration of digital methods in Copenhagen's living labs

Exploration of living laboratories' connection to other labs was done by combination of several digital tools such as *Hyphe, Palladio, or Gephi. Palladio* is a web-based platform for the visualization of complex, multi-dimensional data. Palladio was used to visualize a network of available living labs in Denmark. The network in itself is not trying to create a complete network of all living laboratories in Denmark, as it would require much deeper exploration. The available presented network offers a network that is creation out of connection to Labitat & Biologiragen and ETHOS lab.

Discovered labs from crawling web pages were collected in Excel file, where each laboratory's coordinates were added manually. The data from Excel file were further uploaded to Palladio website, where they were displayed on the map. The linkage on *Figure 4* and *Figure 5* among laboratories was created independently regardless the real linkage. Its purpose here is solely visual, to create an illusion of network. The actual linkage would need to be created manually otherwise.

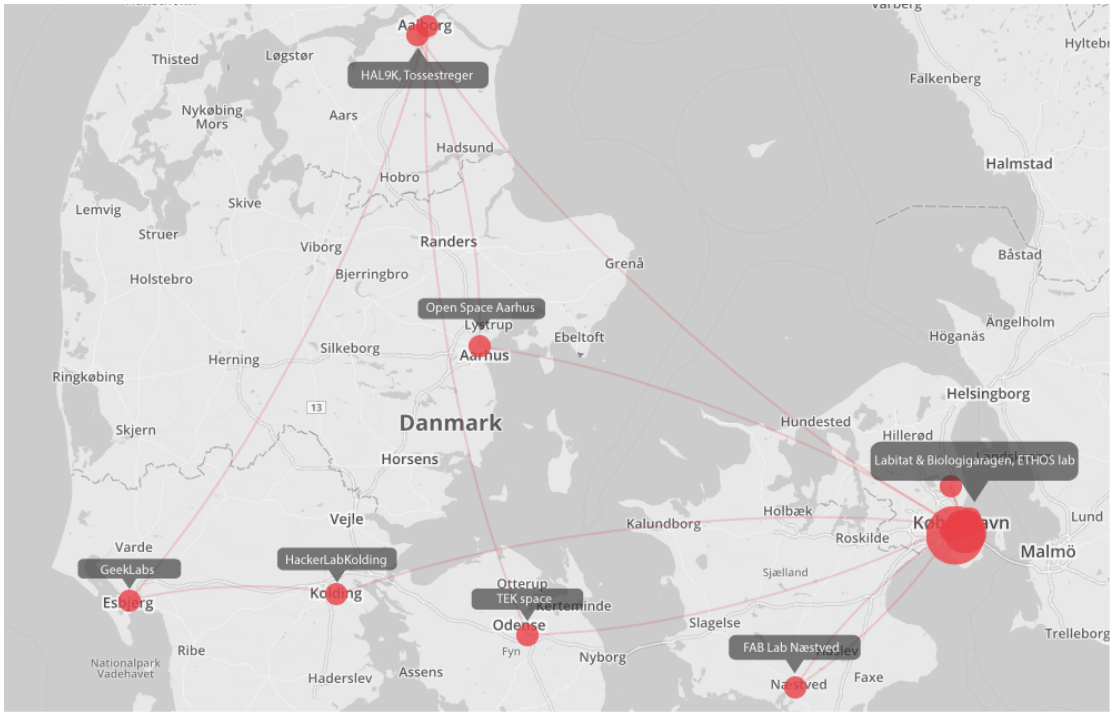


Figure 4. Network of Living Laboratories in Denmark

On the *Figure 4* the attention should be paid to red nodes as they are representations of the living labs throughout Denmark. The grey tags with names of labs are only orientantional due to big concentration of some labs in specific locations. From the map we can notice that the concentration of the laboratories is focused mostly in bigger cities as Copenhagen, Aalborg, Aarhus, Odense and so forth. That could be related to higher number of people with similar interests to co-create these spaces.

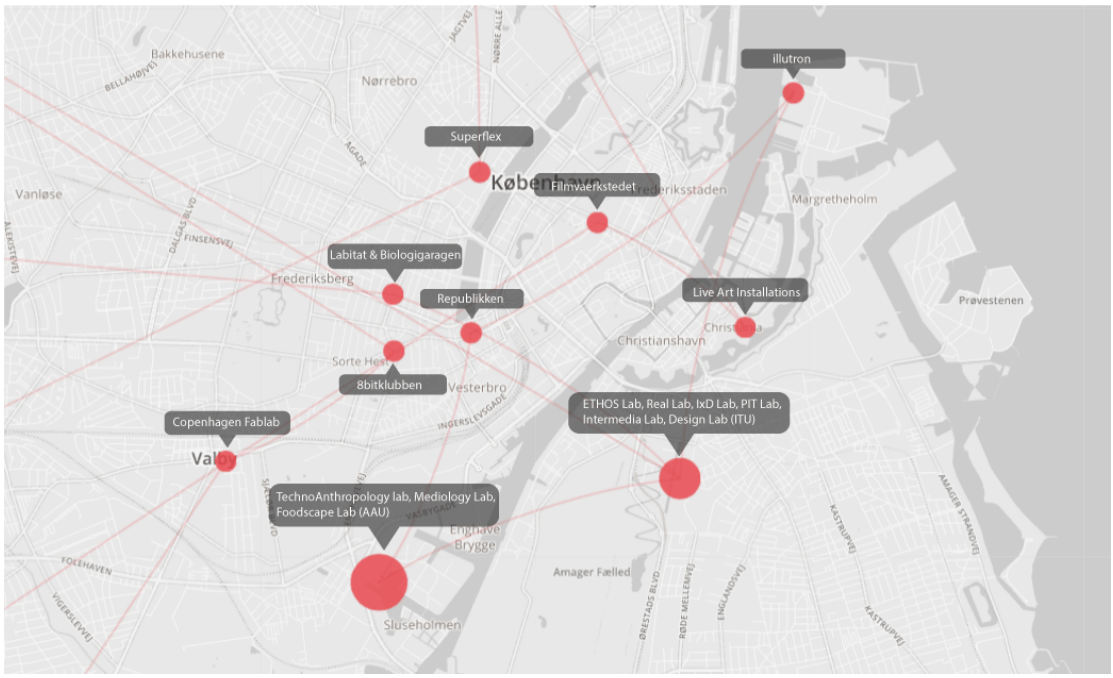


Figure 5. Network of Living Laboratories in central Copenhagen

On the *Figure 5* is close-up of the more central part of Copenhagen, where we can see Aalborg University or IT University. Both universities have a high number of laboratories at their campuses of which many were established quite recently. In *Table 2* will be a complete list of living labs that were used for the *Figure 4* and *5*.

Hyphe is a web corpus curation tool that builds a web corpus, which is a set of web pages that are organized by the user. The user choses web pages that are grouped for instance by their URL as it was done in following example. This allows user to crawl hundreds of web pages and discover their network, where they can be exported as web entities and their network can be visualized and exported into Gephi for further exploration. Unwanted nodes in the network can be discarded manually and boundaries defined by the user.[6]

Gephi is an interactive visualization and exploration platform for all kinds of networks and complex systems, dynamic and hierarchical graphs.[7]

[6] (Hyphe, 2015)
[7] (Gephi, 2015)

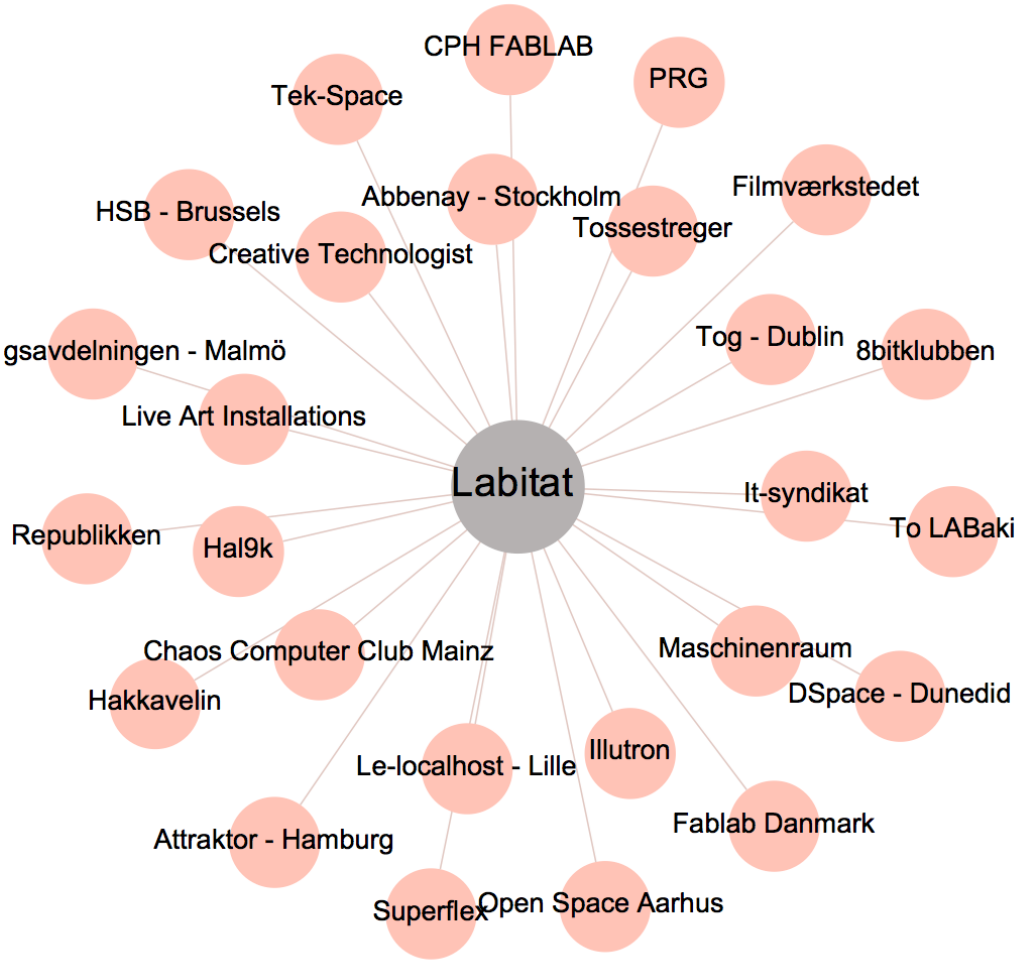


Figure 6. Labitat's page like network on social media site

On *Figure 6* is a network created out of Labitat's website crawl with *Hyphe* and later visualized and edited in *Gephi*. The Labitat's URL was entered in *Hyphe*, where the web page was crawled and new links towards this URL were discovered. In one of the link appeared many names that after exploration of some happen to be other creative spaces that had connection to Labitat. The links to search engines (such as Google) were discarded. The network was downloaded and opened in *Gephi*, where the network was edited by using Force Atlas 2, Nodes rank and color definition.

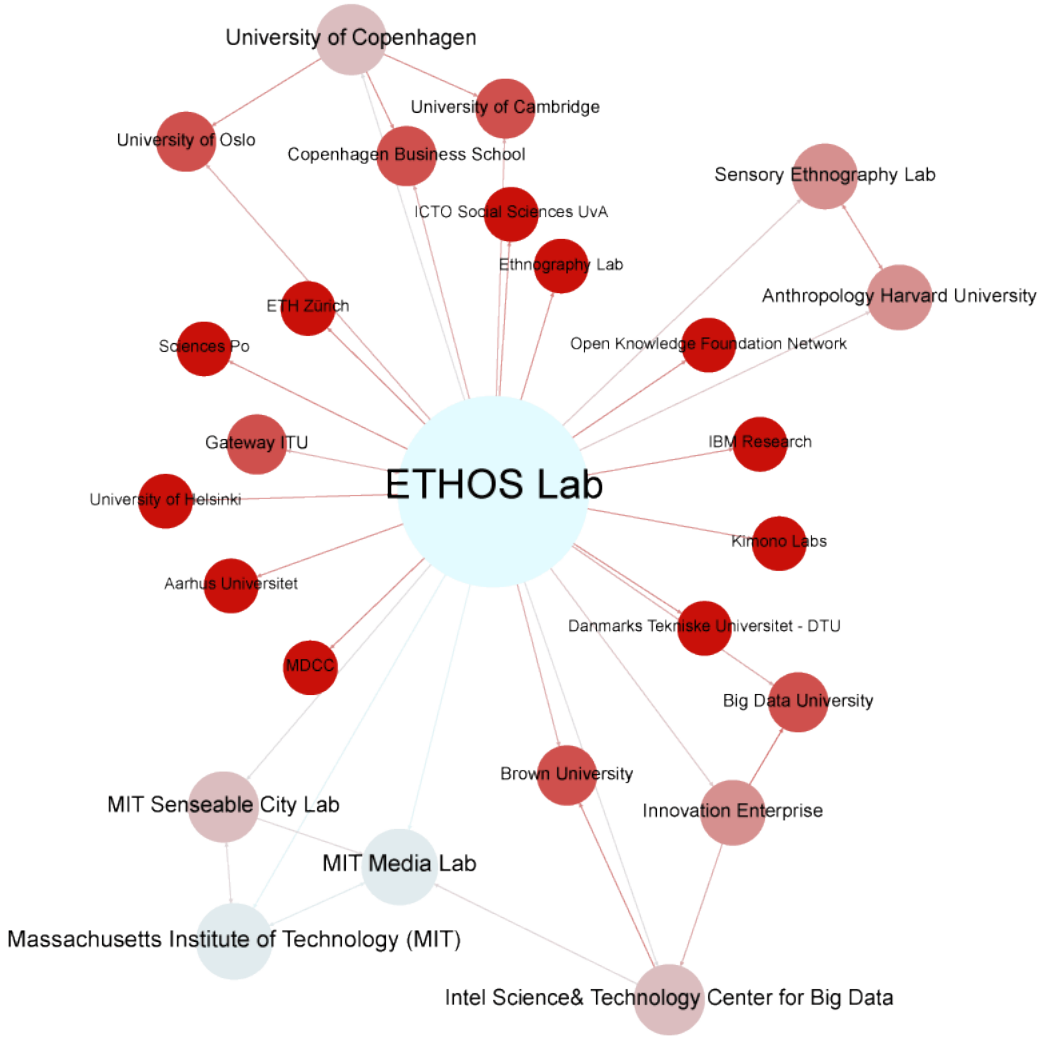


Figure 7. ETHOS Lab's page like network on social media site

On *Figure 7* is a network created out of ETHOS Lab's website. The ETHOS Lab's webpage link was placed in *Hyphe* where it was explored and later visualized in final shape in *Gephi*. From the visualization is seen the linkage to other educational institutions and labs that the ETHOS Lab is associated with.

In further exploration the focus was paid to social media platforms, particularly Facebook. The exploration was done by the help of Netvizz tool, which is a tool that extracts data from various sections of the Facebook platform for research purposes. The focus was on Facebook pages of the three laboratories: Labitat, Biologigaragen, and ETHOS Lab. For the outcome to be useful, particular webpage needs to have activity going on their pages.

Data from each page then can be collected by group data, page data, page like network, search or link stats. For the purpose of the connection exploration was used group data and page like network, which creates a network of pages connected through likes between them. Only Labitat and Ethos Lab were used due to low amount of data from Biologigaragen that were found on its Facebook page.

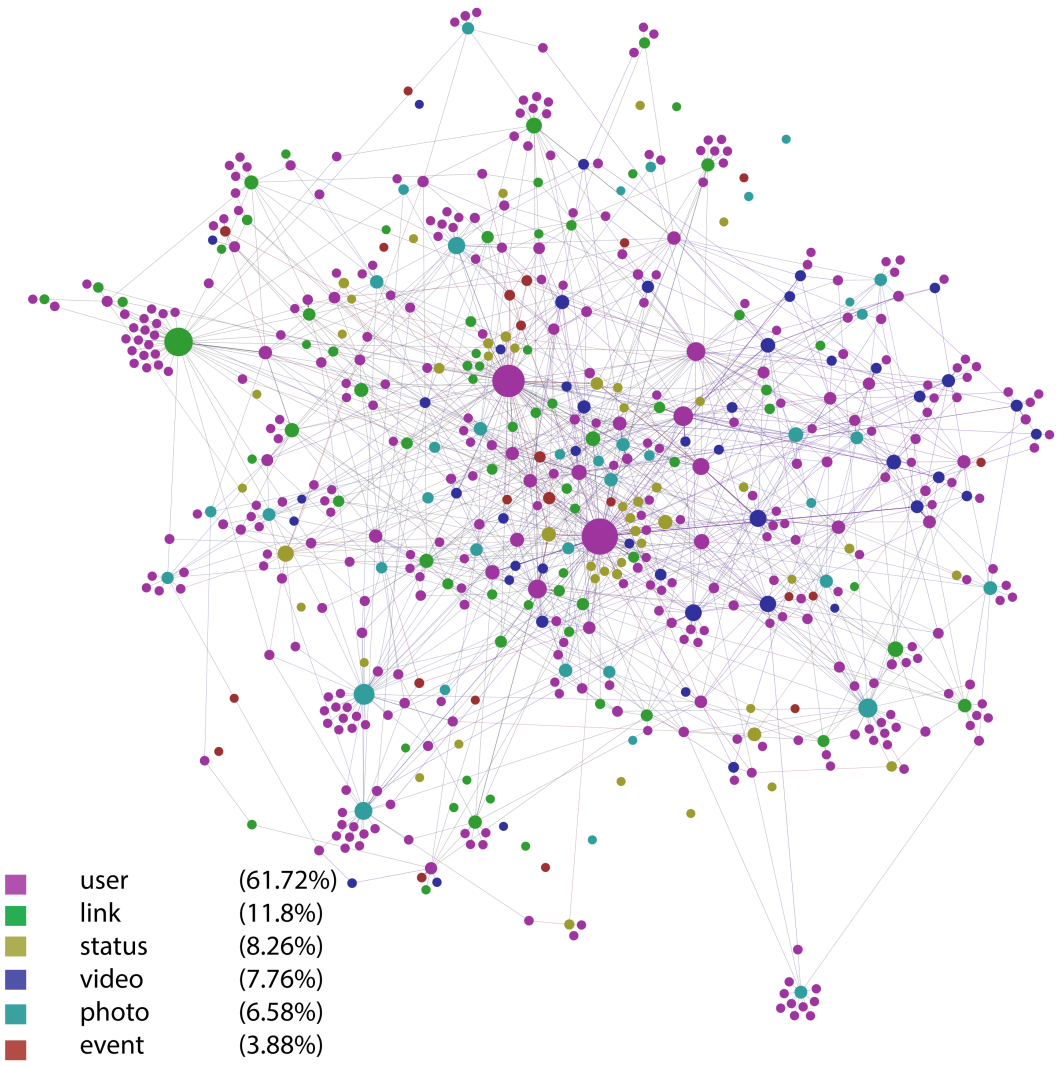


Figure 8. Labitat's Facebook page network based on type of post

On *Figure 8* is the visualization of Labitat's Facebook page. The users, who are either members of Labitat or people associated with the space on Facebook, do the most activity on the page. (Purple nodes) Their most used form of communication is by links (green nodes), where they share things they find interesting with other members.

Event has the lowest percentage (red nodes), which is not caused by Labitat's lack of interest in organizing them.

It is due to that most of the communication is happening in Labitat through their Wiki page where all the information about their activities and involvement can be found. In this case they chose to communicate via different medium than Facebook.

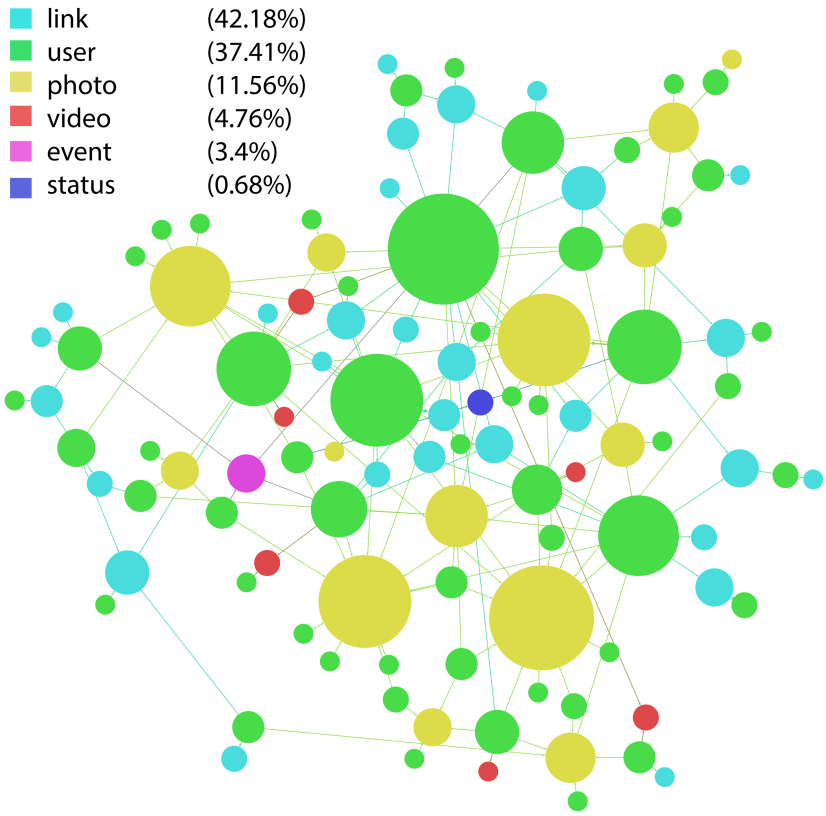


Figure 9. ETHOS Lab's Facebook page network based on type of post

On *Figure 9* is the ETHOS Lab's Facebook page. The users similarly to Labitat's case do the most activity on their Facebook page where they communicate through link posting. (Green and yellow nodes) The Link may contain articles that might be related to what they do in the lab. Further the links are various invitations to lectures, events and literature.

Living Labs
Labitat & Biologigaragen
Ethos Lab (ITU)
Illutron
Republikken
Techno-Anthropology (AAU)
Medialogy Lab (AAU)
Foodscape Lab (AAU)
Real Lab (ITU)
HAL9K
Open Space Aarhus
8bitklubben
Copenhagen Fablab
Fablab Danmark Naestved
Filmvaerkstedet
Live Art Installations
Polyteknisk Radio Gruppe (PRG)
Superflex
TEK Space
Tossestreger
GeekLabs
HackerLabKolding

Table 2. List of living labs that were explored through the relations of Labitat and ETHOS Lab

In this section were used some of the digital methods together with post-demographic methods to explore networks of chosen living labs. Such methods can be complementary to ethnographic methods and others, mainly nowadays when big part of work, communication and interaction is happening in virtual spaces. Through these methods were discovered laboratories that are affiliated with the chosen spaces together with behavior on social media. The downfall of these methods can be lack of data or denied access. Virtual spaces can be a good place to observe a nonverbal patterns and procedures, which can be normally in verbal communication suppressed.

5.1.2. Labitat

Ethos and purpose of Labitat

Labitat is hacker and maker space in the center of Copenhagen in Denmark who shares space with Biologigaragen. Labitat is a space for people with interest in diverse technology. They are independent physical space, working creatively with technology and bridging interactive technology with design, and art. Labitat as an association aims to create a physical space for interdisciplinary cooperation in applied technology, art and fabrication, containing thereto-specialized facilities, and to disseminate knowledge of the emerging opportunities that exist for civil technology. The lab aims to create and maintain collaboration with close organizations both inland and expatriate.

Self-regulation

Labitat as an association has a set of guidelines about their interest and aims, membership system, meetings, finance and so forth.

"The collaborative organization Labitat does biweekly meetings, where the members, who show up, decide how we should run the space, if we should buy some equipment or anything else regarding the organization of Labitat." (Interviewee nr. 2 at Labitat & Biologigaragen: 8)

One can become a member at Labitat under the terms of supporting the association's purposes. To become a member one has to register on the Labitat's website, although to be a member and have a full access to space anytime, one has to contribute.

"Anybody can come and use our space. If they're going to work regularly, they should be members. Mostly to engage them in the running of the space, developing the space and representing Labitat when invited to external events etc." (Interviewee nr. 2 at Labitat & Biologigaragen: 9)

The payment is set by the current tariff quota rate, and it applies to specific coverage period. If one wants to resign membership, it has to be done by contacting a board member. By behaving against the labs interest, one can be excluded from space and his or her membership would be terminated. The general meetings are formed by the general assembly, which is held annually. The agenda for the meeting is sent out to its members, at least, two weeks in advance. At the annual general meetings takes place an election of a chairman and treasurer. The chairman and treasurer (who manages finances) report and present their plans for the coming season. The summary of the meeting is in minutes document that is published on the website of Labitat and available to everyone. The election of a board of directors is held at the general assembly meeting where new chairman and treasurer are elected. The decision is based on the majority of votes that takes places by showing hands. The board is elected for one year. The Board is responsible for the budget and accounting. The treasurer manages finances, especially memberships payments. One board member, as well as either chairman or treasurer, can represent Labitat externally.[8] Some of the members call the way in which they function *semi-anarchistic* or *unregulated.*

"So basically we have electronics group, software group, biohacking group, and the wannabes as we call them. (Laugh) People who are going around and having a great ideas, but I never see them do anything." (Interviewee nr. 1 at Labitat & Biologigaragen: 5)

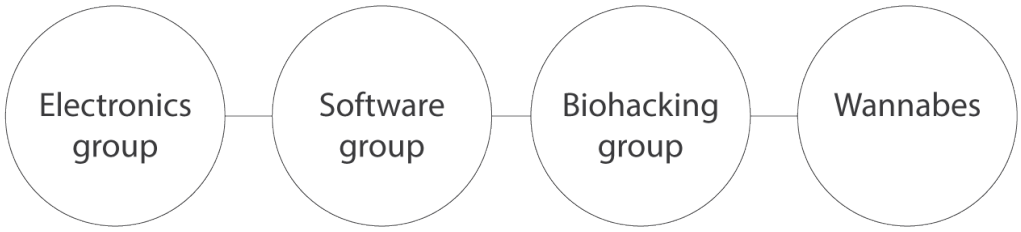


Figure 10. Labitat's organized work groups

[8] (Labitat)

Reality of resources

The fees from its members serve to pay rent and equipment to build tools. Space offers a diversity of tools. There are rooms with specific tools for woodworking, 3D print, CAD drill, soldering, and electronics, etc. The whole space is filled with various parts of devices and *quality junk* as they call it. Labitat collects and reuses all kind of devices, which become part of the project, device or some installation. 3D printer can be seen in the same way as a microscope to allow researchers to see and do and translate things. It is an instrument that allows pushing the boundary of what people can do.

"Hacking is defined as understanding a system down to its basic functioning. Even in small hack projects, you may discover a useful function that no one has thought of yet." (Interviewee nr.4 at Labitat & Biologigaragen: 22)

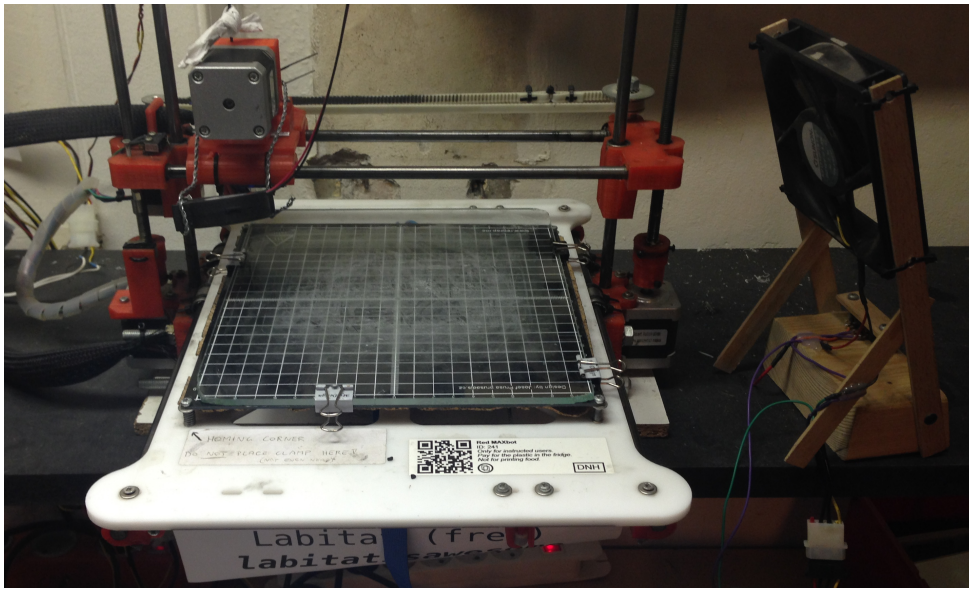


Figure 11. 3D printer at Labitat

Figure 12. Myford machine tool for metalworking lathes

Ideal of access

In the space can be encountered many different people with various backgrounds and interests. Its members consist of students, retired or research driven and employed or unemployed people. The lab has open hours every Tuesday in the evening, where everyone interested is welcome. Labitat could be described as an organism. The processes clash and cohere just like society, arise and vanish together. What characterizes the space are its people, tools, knowledge, and equipment. They are open to everybody and their activities as long as it does not annoy other members.

Freedom

The possibility what people can do in the lab and the freedom is high. There are rules to keep this organism alive and functioning, but the rules are set up in a way they do not interfere with the processes. Labitat has a rule of two minutes, forty-eight hours and two weeks. The processes should be fluid as much as possible. Things are given meaning through tools.

Members of Labitat are very open to talk to people and if one is looking for advice in a project, they are very eager to help. One thing that characterizes Labitat is the openness literally to everyone.

"There is an incredible knowledge that just hovers in this atmosphere." (Interviewee nr.1 at Labitat & Biologigaragen: 2)

The knowledge gets translated into tools and prototypes. The outcomes from this lab are new knowledge created by small communities of interest. The members connect the freedom to explore, hack and learn. Taking things apart and explore what are the possibilities for improvement. However the ontology of Labitat is not only in the playfulness of hacking and exploring, but it might also be more entrepreneurial attitude due to member's diversity. Still, the core of Labitat, the board members attitude what the ontology of place should be is not towards commercialization or making a profit.

"I think people just want to hang out amongst other geeks and tinkers with their small projects." (Interviewee nr. 2 at Labitat & Biologigaragen: 10)

Sustainability

At first sight, it seems like a lot of waste around, which is produced, but most of it is reused. The big pile of components laying in the 'Limbo' shelf at Labitat is mostly brought by the members to left alone there available to be hacked or become a component of a new device or prototype. Every centimeter in Labitat has its purpose and is used to the maximum. In some Labitat's rooms, there are only small aisles, which are surrounded by cables, tools, and equipment. Labitat is aware of its impact on the environment, which means they want to be able to maintain a certain level while using equipment that is mostly donated and reused.

"We don't like the 'use and throw away, and then buy a new one' culture. We like to fix equipment/machines/tools instead of buying new ones." (Interviewee nr.2 at Labitat & Biologigaragen: 8)

Definition of Living Lab

The members of Labitat describe the lab as a space where one can learn about technology, teach and talk to other people, socialize after work among other enthusiasts. The aim in Labitat is also to influence and educate the public in technology and sustainability.

It is an open space with flat structure for public that offers knowledge sharing through different forms of socializing and educating with the attitude towards the environment with sustainable thinking.

Categorization

Labitat belongs to user-driven living lab category for its community interest, whose members are mostly hobbyist. However they are open to all people, no matter what they aims are, whether it is a research project, personal project, or they want to spend time among other tinkers. Its members informally organize the activities in Labitat. The space offers a flat structure with a basic set of rules, which works more as unspoken code how to behave so it is not in contrary with other members. The space offers space, tools, and equipment and serves as a knowledge-sharing repository.

5.1.3. Biologigaragen

Ethos and purpose of Biologigaragen

Biologigaragen is a small organization that follows the same trends as Labitat. They are open for people to join, participate and create workshops. They belong to biohacking community, which is a bit different to hacker and maker spaces according to my interviewee in Biologigaragen. According to whom hacker and maker spaces are comprised mostly of hobbyists who spend their time by hacking devices and making gadgets. However there are exceptions, for example in the Germany or the US the movement in hacker and maker spaces becomes more elitist, where the aim is to make a profit. The movement in biohacking community took off only recently, and it is still in the initial phase. It is a movement back to collaborative effort, *village community style*, which is derived from the lack of trust of people towards bigger corporations where the trust has to be build back again via the community.

"The purpose of the biohacking community is to bring biology in the hands of people, back to people because it belongs to people as hackers did initially with the computers." (Interviewee nr.3 at Labitat & Biologigaragen: 16)

Figure 13. Algebar workshop of Biologigaragen at TransArt festival

Elaborated purpose of biohacking community:

"Trying to seek what part of the biological labs can we bring for people to use, what part of biology can be used and enhanced by people, and how can we revolutionize the way that we do research and the way we use biology." (Interviewee nr.3 at Labitat & Biologigaragen: 17)

Self-regulation

In biohacking community, there is a debate about how to regulate an open pool of knowledge and create fairness for everyone. A lot of interdisciplinary projects take place in the biohacking community, where people collaborate from different disciplines. Sometimes this collaboration can create tension when the intentions of people in the project are not met. In bio-environment, there is a higher possibility to discover something, which goes in hand to patent the discoveries.

Patent wars as it could be called are not only in the biohacking community, but it occurs concerning bigger corporations that could exploit this open pool of free knowledge and use it in their favor. Many other similar living labs like Biologigaragen that strive for recognition and struggle with finances have no means how to defend themselves from exploitation by bigger companies.

"The whole conflict is called 'Elephant in the room'…how do you make sure it is fair...so you depend on the others, because you do not know the others' discipline, you want to share it but at the same time you do not want the guys to take everything and patent or commercialize it or sell it to someone else." (Interviewee nr.3 at Labitat & Biologigaragen: 20)

Biohacking community is working on a solution to that by creating an open pool of knowledge that is open to everyone but with regulation what person can take. To be able to use the pool of open knowledge one has to contribute back, either by agreement or marginal profit. In case, the intention is to commercialize the product for which someone else's knowledge was used.

"We want to have a fair thing and it has to be written. We are focus on fairness; we realize if you don't have it people stop trusting each other and stop sharing back." (Interviewee nr.3 at Labitat & Biologigaragen: 21)

The Interviewee highlighted the issue with educational institutions that they do not share back and only use the open pool of knowledge for their purpose. Therefore, the *binding agreement/set of agreements* as they call it should bring fairness and trust in the biohacking environment, where members of laboratories are protected among themselves, corporations and educational institutions. It should protect these living labs from being exploited. It is a way to protect and take care of each other in biohacking environment that possess big potential.

Reality of resources

The reality of resources is a struggle in biohacking community, where most of the labs have members but lacking space and finances. In Biologigaragen, there is a budget, which is used for payment of rent, workshops, events and supplies. As an *Interviewee nr.3* at Labitat & Biologigaragen said, *it is all in the power of people*. In recent months, the activity of members in Biologigaragen was low together with a number of events and workshops. Therefore, if members are active and trying to seek finances and organize events and workshop, there is a possibility to make some profit out of it, which is not however the main purpose of Biologigaragen. The workshop called *VAGHURT (Vagina Yogurt Workshop)* that was held several months ago was not financially successful. However, it worked in terms what the biohacking community is aiming for, to bring the biology in hands of people.

A recent collaboration with bigger companies such as Novozymes brought to the pool of finances some capital but some controversy as well. Where the company used the space to create a certain product by collaborating together with the members and gave back 100.000DKK. Some members of Biologigaragen would expect more to give back from such large company. Not necessary regarding finances, but as further collaboration and exposure.

"Our potential is so small, we are kids and they are giants. Their potential is so big and they manage to use it really fast and it would be nice if they give back a bit." (Interviewee nr.3 at Labitat & Biologigaragen: 36)

Ideal of access

Biologigaragen is more access driven environment due to its access to technology. As my interviewee described, she hasn't come across anything like that. She described her struggle to join the lab at Technical University of Denmark (DTU), where is a lot of things that has to come into being to be able to have access to the laboratory. Even the university environment is quite close, so how can one have access to tools, knowledge, methods and procedures?

"Access to this kind of stuff is limited and place like this which offers a flat structure with no big machine to move around when you want to decide on something, which is important to be able to do things fast. That provides you quite open access as open as possible. I have not come across anything like that." (Interviewee nr.3 at Labitat & Biologigaragen: 13)

My interviewee describes IT University more innovative regarding access to labs, where there are around six labs to this day.

Freedom

Members in Labitat and Biologigaragen are of different nature. Some of them are eager to accomplish commercially successful product, as the development of spectrophotometer prototype is of an example. These members have various motives to do that. Whether is innovation and discovery driven by financial pressure, or financial freedom is not easy to answer. The reality is not always black and white. Therefore, it would be more meaningful to ask differently. What financial freedom and pressure offer to research and what ratio of combining them together is the most efficient. The Interviewee nr.3 in Biologigaragen reflected on this issue from own experience by being on both sides. Innovation in her experience is driven more by financial pressure, where something has to be put on the market. The freedom is diminished by the financial requirement. On the other hand, when financial constrain is eliminated it allows to be more free in terms of what to do and discover.

"Discovery is something more poetic, it is about dreaming, about being free to do that. Staying in your bed and thinking where can I go and assuming I do not have any pressure or any constraint. Like you assume that gravity does not exist." (Interviewee nr.3 at Labitat & Biologigaragen: 14)

The key point is to co-exist between two extremes. When there is excess of freedom, the pressure helps to be realistic and do things and when there is an excess of pressure the freedom allows thinking outside of the box and relaxing.

As a colleague with whom we developed a spectrophotometer prototype was very much driven by the will to succeed, where the initial idea came from discovering a potential on the market and improving one type of device by making it more mobile and accessible to others.

Sustainability

Biologigaragen shares space with Labitat. Therefore, some of the values from Labitat are translated into Biologigaragen. For example, the impact on the environment can be somewhat similar although some members would have objections. As for instance my interviewee at Biologigaragen.

"Look at all the waste (pointing to 3D printers in Labitat). It is horrible, everything is plastic." (Interviewee nr.3 at Labitat & Biologigaragen: 38)

Figure 14. 3D printed objects

On the other hand, in the lab of Biologigaragen is produced a lot of plastics as well, which they are aware of, but in order to handle experiments it is the necessary evil.

Definition of Living Lab

How is Biologigaragen seen as a living lab through the eyes of the members? It is a place where one can make friends. Do things for fun, explore, experiment and have ease access to tools and equipment in the lab that are usually difficult to access. One can either dissociate from work or continue in the work and lastly Biologigaragen serves as a medium to educate public about science in everyday life.

It is a medium with aim to educate public about science in everyday life through workshops and experiments in the lab with ease access to space, tools and equipment.

Categorization

To fit Biologigaragen into a category, it would be access driven (user-driven). Similarly as Labitat, Biologigaragen is driven by the users that form a specific community of interest with the aim to share the knowledge and educate others. In biohacking environment, it is difficult to get access to tools and equipment that is usually found in the laboratory. Even at the university level, there are some restrictions. Biologigaragen posses the opportunity with access to these kinds of things. It is not however only a space that offers these kinds of services, it is a place to explore, have fun, make 'friends' and feel the freedom to do things.

"I love to work and do what I love…this place allows me to do that." (Interviewee nr.3 at Labitat & Biologigaragen: 13)

5.1.4. ETHOS Lab

Ethos and purpose of ETHOS Lab

ETHOS Lab can be found at IT University of Copenhagen where it was established only recently. ETHOS Lab and REAL Lab at ITU add up to the number of already functioning laboratories. The lab functions as a simultaneous facility for program *Navigating Complexity Mapping Visualization and Decisionmaking* that is taught within *Digital Innovation* & *Management* (DIM) studies at ITU. The argument for the creation of its existence was driven by the demand from its students who expressed the need for further exploration and learning within methods and tools taught in the program. Some members of the lab from different universities had to seek out for digital methods on their own, before the lab was established. The idea was to create a space that could in itself be an experiment with knowledge and infrastructures. The space is characterized by loose open energy. As the Lab Manager said, there are reasons for the emergence of such spaces. In terms of ETHOS Lab that figures more in social science and humanities, which are with regard to applying for money disfavored to natural sciences, the actual lab makes it easier. New and experimental innovation in digital humanities and computational sociology requires collaborative effort and therefore space is needed to facilitate it. Whether other labs such as hacker and makerspaces; *"that is much more to me about the relative cheapness of some of these technologies and then lay folk interest and ability to use them."* (Lab Manager at ETHOS Lab: 51)

ETHOS Lab can have a contribution in science and technology, especially in areas of digital methods and visualization. The lab itself is in its initial phase where the character of the lab is still not defined. By the time when fieldwork in the lab started, many new students expressed the wish to become volunteers in the lab. The lab functioned during the length of the fieldwork as a base for anyone that was seeking help with digital methods and big data. The place served as well as a knowledge space, where people came to work on their projects and help each other out when necessary. The members of the lab come with a different backgrounds and skill level in digital methods. The goal of this lab is to create a community of researchers, students, and partners. Explore new methods, e.g. how digital methods and ethnographic or anthropological methods connect or don't connect.

Combine the skillsets of disciplines and involve people from different disciplines with different set of skills to help develop tools. One of the ideas is to build kind of knowledge sharing/repository from that both students and professors could gain something. In this way professors would get a hold on to new methods which they could teach and students would benefit by being part of it and pair their student's project with the lab. Another aim of the lab is to create university focus.

"University focus is to try facilitate new partnership between universities and external organizations (companies, NGO's)…in a way that ETHOS Lab can become a *connecting point among students and researchers and companies."* (Lab Manager at ETHOS Lab: 52)

Self-regulation

Every Thursday were held meetings where all the lab staff met and discussed what was on the agenda. The agenda usually consisted of status on everyone, where everyone shared what is doing at the moment. The end of the meeting finished off with miscellaneous, where everyone could share with the others anything from invitations to events to the distribution of tasks. The main agenda of the meetings varied based on how the space matured. At the beginning of the agenda was how to divide work among members of the lab to ideas for research projects. By making new connections with external partners, ETHOS Lab organized two data sprints for MindShare and Red Associates. Data Sprints were events where external partner would provide data, and ETHOS Lab would explore it and create patterns for the partner by using various tools and methods. One of the initial ideas was to create a partnership with companies on projects similarly as it is done at Copenhagen Business School (CBS). It is currently undecided, but there are several scenarios that could be applied. The lab could be an institution, which receives money for the work, and students in exchange get experience. The criteria upon which the project would be chosen is academic interest foremost and after that revenue.

"Money would go to lab in order to run different things depending on the amount of money (purchase of the equipment, hiring people for limited amount of time, model where students get the money could be also possible)." (Lab Manager at ETHOS Lab: 55)

The aim of the space is to have a flat structure, but as it turned out it is not easy and requires more time. Instead, there is an *informal hierarchy* and *formal semi-flat* structure. Where people are told that they are free to do whatever they want, because their opinions about what constitutes ETHOS Lab are equal. But in practice, it turned into the requirement of more hierarchical structure. Some of the obstacles in the beginning of the lab were connected to logistic difficulties and defining what the place ought to become and what content is needed. Therefore, the volunteers should help to create community and define the ontology of the lab. The distance between political stakeholders and the lab itself was an issue to some extent regarding communication during the length of fieldwork but started to improve, in the end, where stakeholders showed initiative to be more involved in the processes of the lab. The impact of the lab is meant to have some serious contribution, instead of being only a playground for testing something new and see what happens, which is however part of it as well. The lab's aim is to have some direction and intention to progress and develop.

Some considerations have to do with privacy issues that is still a grey area when using digital methods, where a lot of data has a private origin. ETHOS Labs' justification is that the use is not for commercial purpose, but to gain knowledge about society. Such thing as one of the Lab assistants says should be discussed in public, there should be done some consensus. But currently, there is no law prohibiting the use of data from Facebook and Instagram and other social medias. Related to privacy issues is the amount of data being stored and used about users. There is still hype about big data and how it may affect the society in some way. As Lab Manager said it may result in society being more self-conscious. There will still be things like a crime for example, but we will be able to reflect easily on things we do.

Reality of resources

ETHOS Lab's existence is in the hand of the stakeholders, because they are the ones who decide about lab's existence.

"We pay our rent in some academic/political currency of delivering some results, visibility, on longer-term research paper/output, number of people who use us, affiliation etc." (Lab Manager at ETHOS Lab: 55)

With an emergent number of established labs at the universities, one could speculate about educational institutions trying to bridge the gap with the labor industry, where universities are more entrepreneurship driven. The promise of ETHOS Lab bridging the gap may be there, but it is not the main reason for the ETHOS Lab's ontology. A number of political vectors stand for the creation of any lab according to ETHOS Lab Manager's words. The stakeholders use this kind of *academic/political currency* to argue for the lab's continuous existence. The lab is equipped with several stationery computers and planning to acquire interactive screen board and other things to increase space's usability. Part of the lab is as well small library, which serves as a knowledge repository.

Ideal of access

There is a correlation between hacker/makerspaces and ETHOS Lab in terms of taking things apart, learn how they work and improve or use them in projects.

"I think we want as many people as possible to work with the tools, so to show how easy is to get data. Everybody can make visualization." (Lab Assistant nr. 1 at ETHOS Lab: 64)

Disfavored position with regard to applying for money is described by one of the interviewee, who comes from different university. He expressed his frustration towards collaboration effort in his studies. His background is in Media Studies, where he mentioned some collaborative effort, but not sufficient and lacking structure and with too many restrictions that would allow collaboration. In his words: *"the hierarchy in the universities is also…they prevent collaboration."* (Lab Volunteer at ETHOS Lab: 70)

At least, that was what he experienced in his field of study, where he felt like not being heard compared to other disciplines where students are (such as chemistry and physics). Therefore, he thinks that ETHOS Lab is a very good initiative for humanities and social science disciplines to support collaboration. The lab itself can have a number of impacts on society and science and technology.

"In terms of societal impact, the lab is trying to build alternative public-private partnerships that aim to rework how the university works with external partners. This can in itself change the knowledge economy." (Lab Manager at ETHOS Lab: 58)

Currently, there is one person who develops tools that are being used in the lab. However, the members of ETHOS Lab started a study group where they learn to code in Python language. It is to increase the number of people who could create tools when it is necessary for projects. At this point, the tool developer says that everything should be open, and the only thing that would be required is to be mentioned as a tool developer when someone would use the tool in the research. The use of tools at ETHOS Lab is to analyze and interpret, which changes over time. Such tools can be used for the various and broad spectrum of purposes. Compare to Bio environment where devices are being developed to have one specific purpose.
Another consideration relates to patent creation. The lab itself is not against people trying to develop something with business potential. The intention is to keep tools, algorithms and services open, but of course, there is a possibility of things not working in the way as it is sometimes imagined. As Lab Manager says:

"It is actually unclear legal area, since those of us who are employed actually have to accept that the ITU owns part of patents we come up with in our work-time. I have no idea how that would work if there were volunteers involved in the process. But I hope that we are able to keep our activities in an open source spirit and environment." (Lab Manager at ETHOS Lab, Email interview: 59)

Freedom

Freedom to explore, hack and learn is important for the ETHOS Lab to some degree, which has strict goals with research and volunteers' interest to participate. The ETHOS Lab is a sort of regulated medium between a corporation and hacker/makerspace. On one hand there is a whole lot of freedom, but on the other hand, it is required to deliver something with volunteers' help in the daily activities and staff's bounded tasks to Navigating Complexity course. The innovation and discovery are driven by both financial pressure and financial freedom. Lab Manager at ETHOS Lab believes that research should be free in terms what to do, *to try stuff out without repercussions.* But on the other hand, it would be naive just to say: *money for everyone and just go crazy.* To what one of the Lab's Assistant adds that ETHOS Lab has an advantage of being at the university, which results in freedom from financial pressure.

Sustainability

The lab does not produce any visible waste in a sense. Therefore, it is difficult to measure the laboratory's approach and impact on the environment. The only thing that relates to big data regarding impact is the data storage that requires energy. ETHOS Lab in this sense does not have a big impact as for instance Google might have in terms of data storage.

Definition of living lab

What is the lab as a meaning and symbol for its members? The ETHOS Lab members describe the lab as a place that has to do a lot with social, where people meet with similar interest. They can work in the lab in semi-isolation. They can decide to work on their thing, but the proximity of the others makes the social that allows them to discuss, share ideas, opinions, and help each other. It is a place where people can experiment, collaborate and cooperate on projects.

It is an intellectual open social space for people with shared interest that allows collaboration and experimentation in semi-isolation.

Categorization

ETHOS Lab comes under the categorization as a provider-driven and user-driven living lab. As the Lab Manager says:

"ETHOS Lab is a provider-driven but also user-driven, that is the whole idea of the volunteer base. We try to facilitate a space where people can do what they are interested in." (Lab Manager at ETHOS Lab: 50)

The category of provider-driven living labs is that they develop solutions or have an educational purpose. Some of the benefits such a lab can possess are new research outputs. This space can operate in virtual or localized environment. The user-driven living lab is focused on the needs of individual users or user communities, which are built around them. The Lab Manager of ETHOS Lab believes that lab is user-driven due to its approach towards volunteers, who are the users of the lab.

"But I see volunteers as users in a sense…who will become affiliated with the lab…volunteers are part of constituting what the lab is about through the research that they do." (Lab Manager at ETHOS Lab: 50)

There is an informal hierarchy at ETHOS Lab, where members (users of the lab) are suggested what to do. Another influence is from the political stakeholders (Head of the lab) that are part of the research group at ETHOS Lab. However, the stakeholders are not involved in such extend, as Lab Manager of ETHOS Lab would wish.
Even so the lab tries to create a bottom-up approach with its volunteer's base. Therefore, it is a mixture of provider and user driven with informal hierarchy approach implementing some of the bottom-up processes. It behaves as a semi-regulated medium in terms of research.

One of the volunteers hopes that space like ETHOS Lab and other experimental open labs will be part of bigger research community in the future. Especially in the current situation, when new government in Denmark cut down one-third of open research funds.

"But there are some funds allocated to research that does not have a apparent purpose but it is just experiment and they just cut third of the funding with new government in Denmark. With that I think it is even more important to have labs where experimentation takes place, because else we will get nowhere, we will all stagnate." (Lab Volunteer at ETHOS Lab: 72)

5.1.5. Reflexive summary of Analysis I

In *Analysis I* were explored two cases where fieldwork took place. Each space presented offers a different attitude to living labs, yet there is a certain value that connects them, and that is their commitment to the value of sharing knowledge throughout the space and network and the will to learn and educate others throughout collaboration effort. However, yet for member or a person visiting a living laboratory the space constitutes something different too. The value of sharing knowledge works within and outside the network of the lab and it is up to the individual what one makes out of the shared value and to what purpose it should be use for. Each space will offer various sets of tools, equipment and knowledge together with rules and etiquette.

"Is it just a hobby/after work chill out place like Labitat, or is it trying to encourage entrepreneurship and business like DTU Skylab, or is it trying to educate the public about science in everyday life like Biologigaragen?" (Interviewee nr.4 at Labitat & Biologigaragen: 22)

Living lab cases were analyzed based on the research question and dimensions from *Living Lab ontology I*. The existence of the lab is dependent on the member's activity. In the case of Labitat, Biologigaragen or ETHOS Lab if there were no members it would lead to the end of functioning the laboratory. It is members who create a community of interest, provide tools, equipment and co-create the sharing knowledge ontology. Living lab nature is to be open to the public who they seek to involve in the activities of the lab or educate them about technology. There are numbers of various living labs that are formed around communities of interest, which is the most important factor that constitutes their existence.

Living labs presented in *Living Lab ontology I* are conceived as a topic in user and open innovation that is bound to economy where user communities serve to validate new technology. A considerable amount of literature addresses the lab as a drive of economics and social change. Further living lab is described as a site where users (members) of the lab share equipment between each other that is provided by the members.

The most comprehensive research is done by Leminen et al. (2012) that offers categorization among labs. They offer characteristics of four different types of networks that companies can benefit from knowing. The result of this chapter is not a guide that supposes to help companies to navigate efficiently among living labs and how they could benefit from them. The ethnographic fieldwork of this thesis investigates two cases of living labs to a greater extend. In particular, the fieldwork enlarges the characteristics investigated by Leminen et al. (2012) where they categorize living labs into four categories enabler-driven, utilizer-driven, provider-driven and user-driven. The characteristics are elaborated by broader a set of dimensions listed in *Table 3.*

	Labitat	Biologigaragen	ETHOS Lab
Purpose	Labitat as an association aims to create a physical space for interdisciplinary cooperation in applied technology, art and fabrication, containing there-to-specialized facilities, and to disseminate knowledge of the emerging opportunities that exist for civil technology.	The purpose of the biohacking community is to bring biology in the hands of people, back to people because it belongs to people as hackers did initially with the computers.	The purpose is to experiment with knowledge and infrastructures, while creating community of students, researchers and partners. It should serve as knowledge sharing repository where different skillsets of disciplines are combined.
Self-regulation	Biweekly meetings, anual general meetings, set of rules, orginized work groups.	Open pool of knowledge that is open to everyone but with regulation. Anual general meetings.	Weekly meetings. Informal hierarchy and formal semi-flat structure.
Reality of resources	Members' fees, diversity of tools and equipment, quality junk.	Common budget, equipped lab with tools.	Academic/political currency, equipped lab with books and computers.
Ideal of access	Open to everybody.		Open to everybody.
Freedom	Non-regulated	Non-regulated, co-existence of two extremes.	Semi-regulated
Sustainability	Fix and reuse culture.	Awareness of the impact on the environment.	-
Definition of Living Lab	It is an open space with flat structure for public that offers knowledge sharing through different forms of socializing and educating with attitude towards the environment with sustainable thinking.	It is a medium with aim to educate public about science in everyday life through work-shops and experiments in the lab with ease access to space, tools and equipment.	It is an intellectual open social space for people with shared interest that allows collaboration and experimentation in semi-isolation.
Categorization	User-driven		Provider and user-driven

Table 3. Living labs' dimensions

What we learn about living labs in Copenhagen and what tensions and challenges they face? Following dimensions are summed up in *Table 3* where they are listed in as comparison next to each other. Each lab is unique due to its members who establish what the lab constitutes. The way they chose how to be regulated depends on the nature of the lab. The members can co-exist within a flat structure, or semi-flat structure as it is in laboratories that are part of educational institutions.

First time entering the lab can be exciting, but also very confusing. Some users may tend to be lost or seek guidance in terms what to do. An example of such a situation is ETHOS Lab where volunteers are suggested what to do. Therefore using informal hierarchy as a way to guide the others solves the challenge with members of the lab. The situation might change in the future when volunteers will come with their projects and related problems what Lab Manager at ETHOS Lab hopes for. On the other hand the members in Labitat work on their projects and are open to help others. Nonetheless, the informal hierarchy does not exist there. Nobody is told what to do. If someone wishes to sit in the corner and do nothing, one is allowed to do so. The flat structure has advantages, but coming from the environment where prevail hierarchy (education, work, family relations) can trigger confusion. Another challenges and tensions are in terms of resources, where members struggle to pay rent, they lack space or membership base. (Interview with Interviewee nr. 3 at Labitat & Biologigaragen) Living labs such as Labitat and Biologigaragen wish to educate the public, despite their effort it happens that they may be exploited by the other corporation or other entities. An example of that tension is an exploitation of laboratory's members to do things for free without sharing back with some counterbalance as recognition or small donation. Another tension is related to patents, which creates tension especially in biohacking community where it is necessary to act by creating binding agreements among participants.

Living Lab ontology I and *Analysis I* help us to understand what living laboratory really is by offering a view from the inside. Where it describes how the lab functions with related tensions and challenges in practices.

5.2. Analysis II

In *Living Lab ontology II* were presented research methods that help to understand living labs. Laboratory is a very complex set of practices and *Living Lab ontology II* is used as an instruction manual to orientate in the lab. First was introduced relation of objects and subjects in different realities on the example of Mol (2002). How objects are enacted in different practices/situations that are part of multiple realities and how these objects are located in spatialities of the hinterland.

In *Analysis II,* will be presented two examples in living laboratory based on the *Living Lab ontology II*. The first example will be *Data* at ETHOS Lab and how they move in the network and change its shape based on the spatialities. It is to understand better the living laboratory on an example from the practice. The second example of spectrophotometer prototype will be more substantial. It will be described on Annemarie Mol's example of atherosclerosis. The example that correlates to Mol's atherosclerosis will be shown as the event called *absorbance measurement*. The purpose is attempting how to understand reality in the living lab through object/knowledge that is enacted in the practices.

5.2.1. Data as enacted object in multiple realities

The data is presented here as an object manipulated in practice. When volunteers or students are working on the assignments for the course of Navigating Complexity, they work with some statistical data that has been collected in a virtual environment (e.g. Facebook). For this example, they use software such as Tableau or Gephi to make sense out of data by simplification and visualization. The data changes its form from a cluster of raw data when it is in Excel file all grouped together under several headlines and later when it becomes a node in Gephi or column in Tableau. The data floats from one kind of software to another and changes its shape. As an example could be used Data Sprint, where the present members of ETHOS Lab are given certain data. Members form groups to work together how they want to approach data, and they may use each different tool to accomplish it. If we have a three groups working with the same data, the output or the meaning derived out of it may not be the same. For the first group working with Tableau, the outcome may be some graph illustration. For the second group working with Gephi, the outcome may be some network with nodes and edges. And for the third group working in Excel, the outcome may be some ordering or scatter plot illustration as seen in *Figure 15.* Therefore, the data can be used, interpreted and give meaning in various ways. The same data can become a cluster of something and have a new meaning.

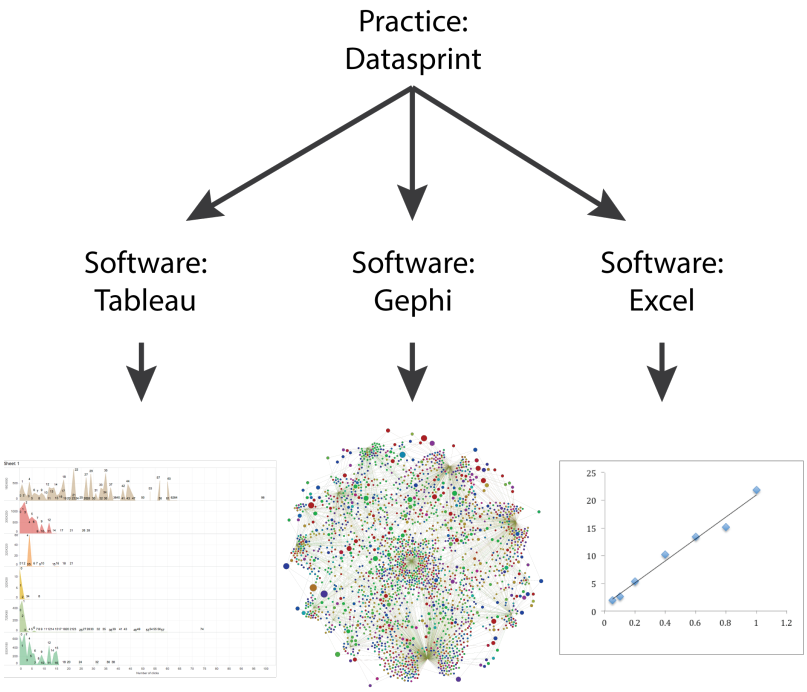


Figure 15. Data as enacted object in multiple realities

The meaning of the data can have is more than one it has multiple meanings. It can be fragmented and used differently with software and members using it. It behaves based on the software in different ways, as it is given a command/role how to behave beside other data in a cluster. To make sense out of data requires many actors to come together. In the situation of datasprint are present various actors (computers, members, software, room, tables, chairs, data, etc.) The implication of data in this practice is that by manipulation we create meaning about something. It helps the learning process. It helps for digital methods tools development to make sense out of data and understand by manipulating them. The members of the lab contribute and gain from the learning process. Data is here as a good example of fluid spatiality, it is mutable mobile. It changes its shape while being transported.

5.2.2. Spectrophotometer prototype

To understand reality in living lab will be used an example from fieldwork. The aim was to develop a portable spectrophotometer prototype that would offer visual record and decrease in size compare to the usual spectrophotometer.

The event called *absorbance measurement* requires several actors at once to be involved. To understand this phenomenon called absorbance measurement, I will derive from Annemarie Mol's study of atherosclerosis in *The Body Multiple: Ontology in Medical Practice*. It is to understand an object as things that are manipulated in practices instead of the central point of focus of different people's perspective.

The phenomenon/object is called portable absorbance/ transmittance spectrometer. The aim was to build a small footprint portable absorbance/transmittance spectrophotometer to analyze the concentration of coloured liquids. The advantage of this device would be mobility, small size, and photographic record of the sample compare to traditional laboratory spectrophotometer. A spectrometer measures the wavelength of light spectra. It can be used as an analytical instrument for different processes where particles are dispersed depending to some attribute (mass or energy), and the dispersion is measured.

Background of the spectrophotometer prototype project

The coloured liquids are comprised of particles that absorb incident light and emit only a certain wavelengths. This is how the color of a substance is perceived. In this experiment was investigated the concentration/amount of coloured particles in a liquid by providing illumination with a specific wavelength.

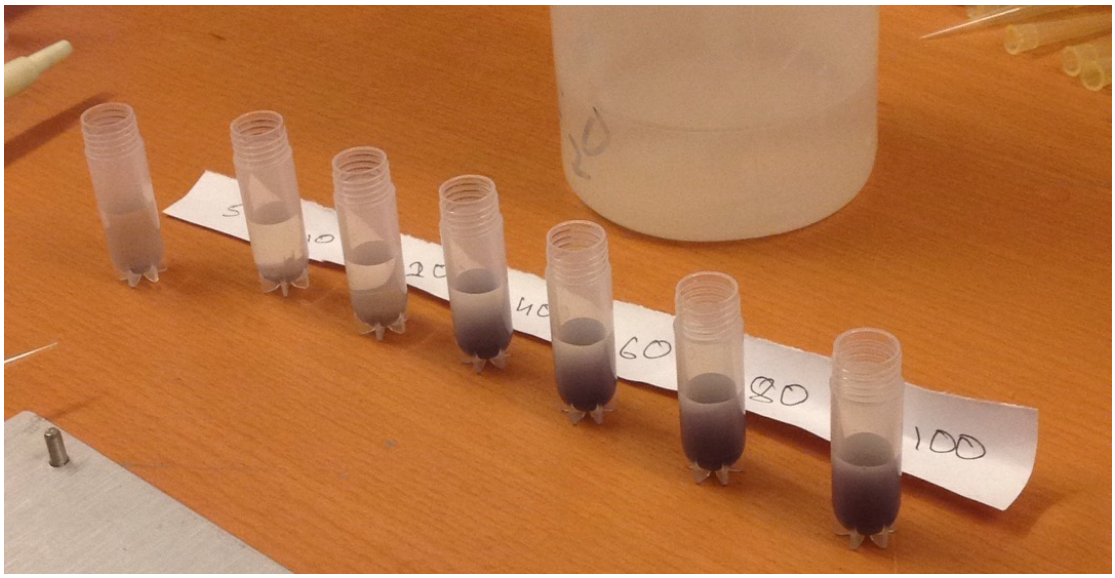


Figure 16. Various concentrations of Iodine and Starch substance in test tubes

Depending on the substance to be investigated, the wavelength at which it absorbs the maximum amount of light was used as the illumination source. The particles ought to absorb light proportional to their concentration, and a fraction of the light ought to pass through the liquid.

An array of photodiodes was used (e.g. light/color sensor) to detect the amount of light that passes through the liquid. By measuring the transmitted light using a sensor, it was applied a beer-lamberts law (measured absorbance is achieved by combining a wavelength-dependent absorptivity coefficient with the path length and the concentration) and relate the quantity of transmitted light to the quantity of light absorbed by the liquid.

A standard graph was first prepared using known quantities of the target substance. This graph was used to optimize the sensor for measuring unknown quantities.

It was important first to calibrate the instrument because it may have limitations as compared to high-end laboratory spectrophotometers.

The standard graph of absorbance vs. concentration must be linear as beer-lamberts law shows a linear relation between the concentration of a substance and the light it absorbs.

The act absorbance measurement requires several practices in which is manipulated. In order to be practiced two of the practices are required. Whether it is a spectrophotometer prototype and sample or sample and software. The practices could be divided into four categories. An important role in the absorbance measurement plays the object (spectrophotometer), the sample of concentration on the lab filter paper (sample), the software in the computer that is to analyze the sample (software), and database to compare our result with others to get the final result (database). These practices are affected by other factors. It is the environment where the objects are handled, the person who manipulates those object, handles samples, and controls software and results. Other members of the space and their practices affect the environment where the objects are handled. The absorbance measurement is enacted in four different practices where it is manipulated. The object differs in each practice where it is manipulated therefore it multiplies a reality. The event absorbance measurement is made out of several practices, multiple objects where they hang together. They take place only in the act then and there where it is being enacted.

The object (spectrophotometer) is enacted in several situational practices that are derived from data diary (Appendices). To understand the hinterland of the living laboratory, it is necessary to be involved in the daily practices. Four situational practices will be presented. The first practice is the laboratory, the second practice is the process of measurement, the third practice is the 3D printing, and the fourth practice is the electronics.

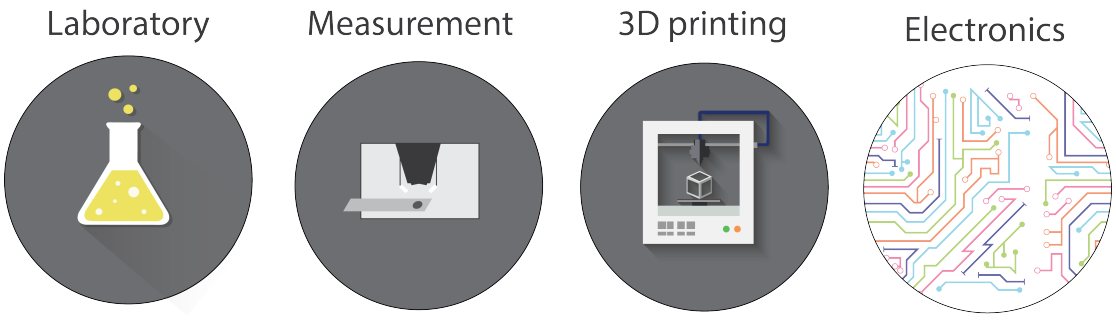


Figure 17. Four different situational practices

First situational practice

Laboratory is the place for preparation of all necessary actors for absorbance measurement could happen in Biologigaragen. In the laboratory were prepared all necessary equipment and tools from cutting filter papers in ready-shape for samples, making samples of iodine and glucose in test-tubes with different level of concentration, starch mixture preparation, pipette handling, using vortex mixer for mixing concentration of starch in test-tubes, and using laboratory spectrophotometer and prototype of the spectrometer.

For the sample on the lab filter paper was used iodine concentration with glucose. This example was chosen based on its easy execution. The starch contains glucose and in combination with iodine, there is a reaction in color. Filter papers, which were used for several samples of iodine reaction with glucose, were the first type of samples that were created. The procedure was to apply different concentrations of iodine on the filter paper with the pipette, which were appropriately marked. On top of these iodine samples were placed a starch concentration with the pipette to create a reaction. Each sample on the paper was of different concentration of iodine and starch, therefore, the reaction was different. A number of exercises were applied until the results became of a linear curve in the Excel sheet that was the aim to achieve, where starch concentration was compared with corrected pixel density. The reasoning to achieve a linear result correlates to beer-lamberts law. Where the achievement of linear results of our spectrometer creates validity for known values. And therefore, the absorbance measurement process can be moved to unknown samples.

Further the experimentation with the sample filter papers took place. The aim was to create a sample paper that a person who would use the spectrophotometer could use to place their sample of concentration on the sample paper and analyze it in a spectrophotometer. The experimentation was with different kind of shapes that filter paper was cut into and different kind of layers on top of each other. This exercise required a lot of patience and precision in cutting the filter papers in the right shape. One of the issues was with the drop of concentration flow on the sample paper, which was solved by experimentation with numerous prototypes of sample filter paper. The goal was to find the right shape and layers set-up to increase concentration flow on the sample paper to create a reaction that could be measured in the spectrophotometer.

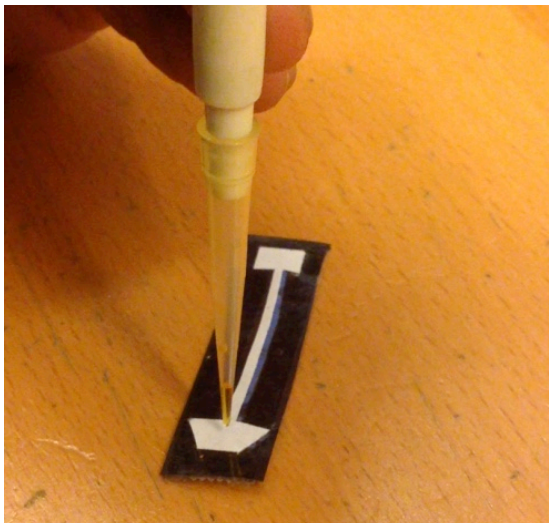


Figure 18. Application of Iodine concentration to create a reaction with starch on the filter paper that was adjusted in a way that the concentration of Iodine flows more efficiently from one side to other

Vortex mixer was used to mix up the concentration of starch with distilled water in test-tube to create an equal distribution of concentration where the sample by pipette was taken and placed on the filter paper to react with iodine sample.

Laboratory spectrophotometer was used next to prototype spectrophotometer to compare the results from both devices to deduce the correctness of measurement of our prototype spectrometer. Laboratory spectrophotometer was clean out before actual use, after solute was added, it was set to desired wavelength and blank cuvette was inserted. The spectrophotometer was calibrated and ready to use.

Second situational practice

The process of measurement required several actors involved. To measure the spot on the filter paper where reaction happened, the actual spot was needed. Further was required a software in which the spot would be recorded and analyzed from which the data would be derived that would be given a meaning. Therefore, there were actors such as a spot on the filter paper, software, data, and given meaning to data.

In the early process, some of the low concentration created a low intensity of reaction on the filter sample paper that was hard to analyze with software. It was due to incorrect handling of concentration that has not been appropriately dissolved in the test-tube. It was fixed by using vortex mixer before every sample was taken from the test-tube.

A phone camera was used to record a spot in prototype in the early process, which was changed for a webcam later on, that was hacked and adjusted to work appropriately.

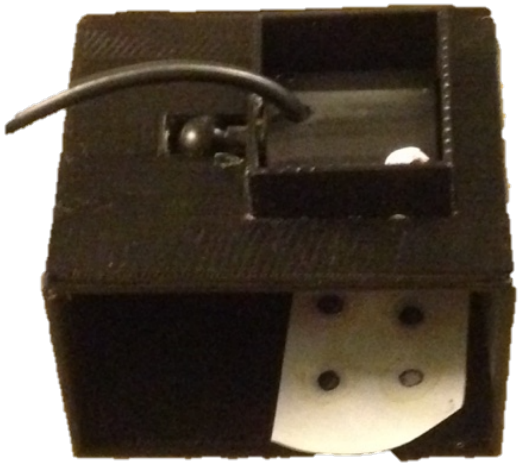


Figure 19. Spectrophotometer Prototype I

Figure 20. Spectrophotometer prototype II

A software ImageJ was used for the analyses of spots on the filter papers. ImageJ is open source software that is written in Java and is available on all kinds of platforms. In the software the recorded images were converted to monochrome and the pixel density was analyzed and results were recorded on the paper that was re-written into Excel table. In Excel, the corrected pixel density was compared to starch concentration and visualized with the trend line to see whether the results are linear or not.

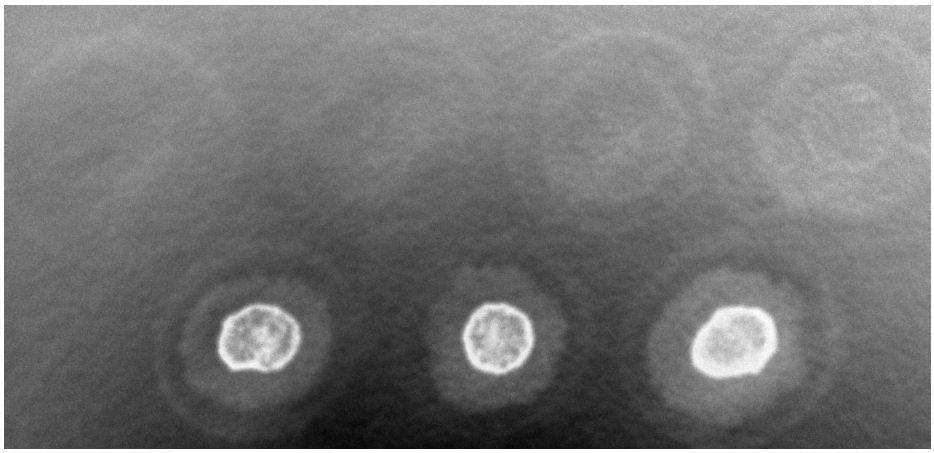


Figure *21. Image analysis of chromatographic detection*

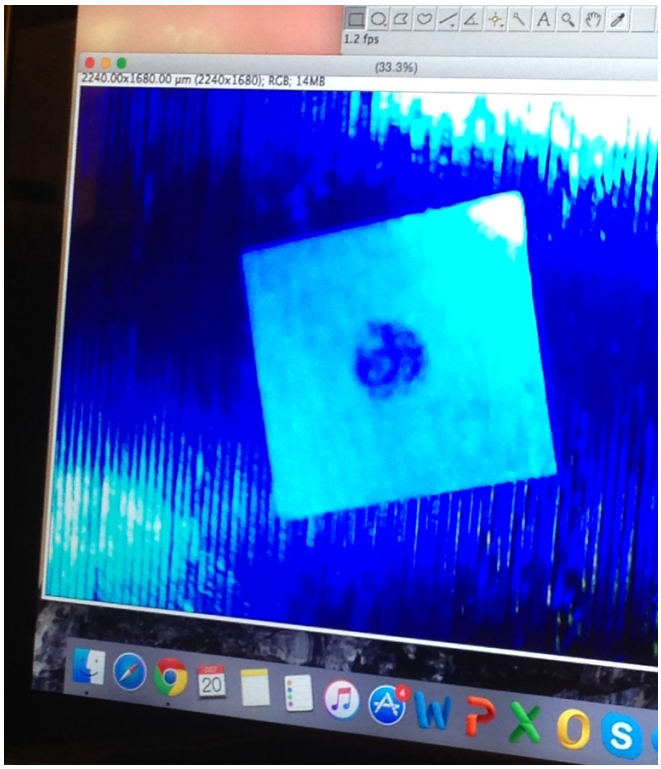


Figure 22. Sample analysis in ImageJ software

Third situational practice

3D printing was the third situation where the actors were a 3D printer and different kinds of software where the 3D model was created and manipulated to prepare for print in the '3D print room'. In the 3D software, *123D Design* has created a model of our spectrophotometer prototype, which was moved to *3D Slicer* program, where it was set to print. There were several prototypes that were created, where some of them have found its purpose and some of them did not. The prototype changed accordingly with the electronics that were part of it and a camera that was used.

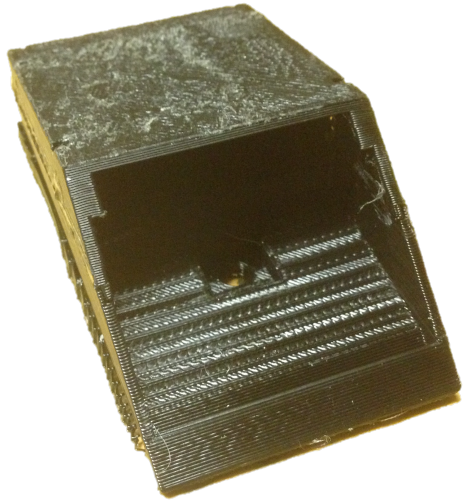


Figure 23. 3D prototype I

Figure 24. 3D prototype II

Fourth situational practice

The 'heart' of the spectrophotometer prototype is the electronics that were part of the fourth situation. For the prototype were used Arduino components and tools and equipment in Labitat. Besides testing and conducting exercises in the laboratory, it was a practice that required a lot of time. The practice involved soldering all sorts of components such as LED diodes, wires to Arduino components and writing code in the computer to behave accordingly.

Two prototypes were built. One that used RGB color sensor and RGB LED. Where the sample with iodine and starch concentration was placed between the RGB color sensor and led diode and measured. The second prototype was using a camera and eight diodes. In the early process, it was used a phone camera and one LED.

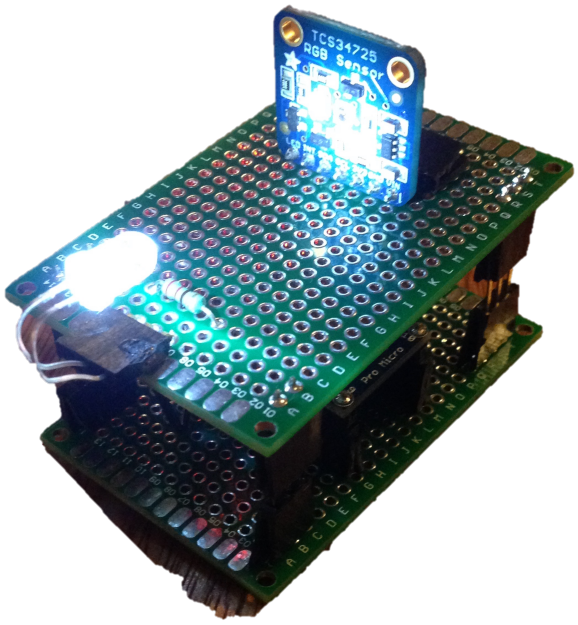


Figure 25. Prototype

Figure 26. Prototype II

5.2.3. Spatialities

In this section were applied four different spatialities region, network, fluid, and fire in which objects are handled. It is an attempt to apply spatialities model on practices handled in living laboratory. The act absorbance measurement can be located in four spatialities as portrayed in *Figure 27*.

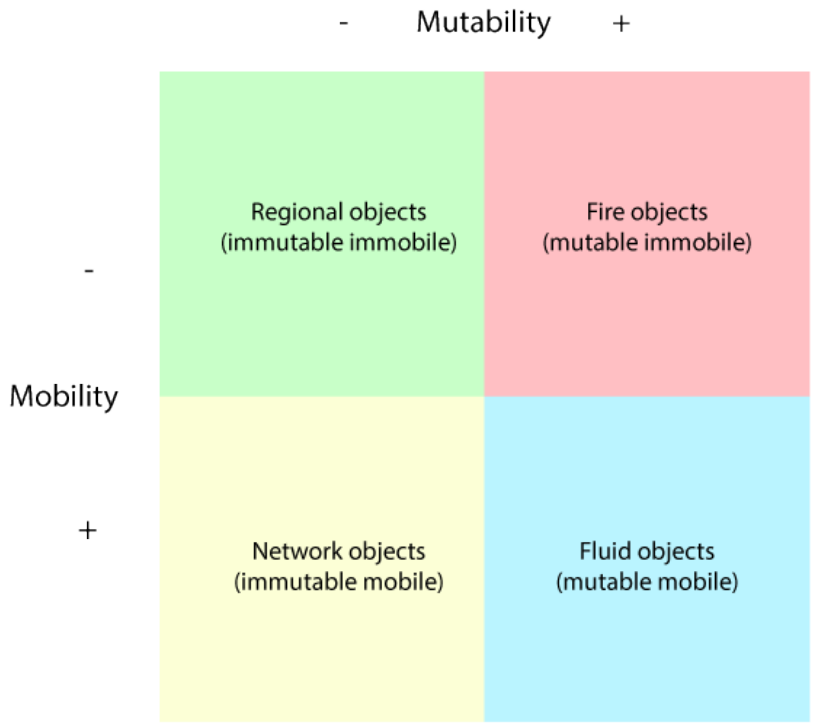


Figure 27. Spatialities

When photo record of the measured sample is taken, it is located on the computer. It is there and nowhere else it is *immutable immobile*.
In a case the record has been transported through a network, from one computer in the laboratory into another computer in the office it means it is mobile and as long as the photo record has not been changed it is immutable. Therefore, it is *immutable mobile.*
From the starch concentration in the test tube is taken a sample, which is placed on the filter paper where it reacts with iodine.

The filter paper is then analyzed in the spectrophotometer prototype, where the picture is taken by the software and translated into data that is later analyzed and converted in Excel into a graph. In this sense, the object changed its location and shape. Therefore, it is *mutable mobile*.

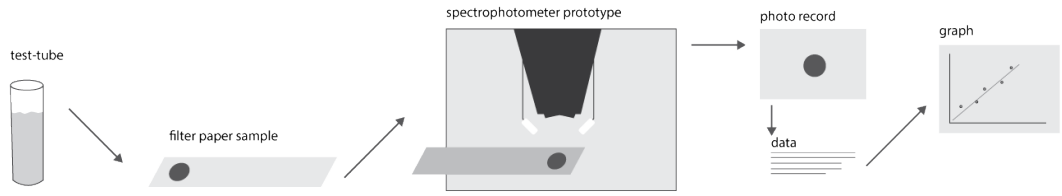


Figure 28. Mutable mobile object

In the fourth example of fire object, it is the conjoined alterity, the absence, and presence, the consistency lies in the abrupt discontinuous movements. It is for example the language, knowledge and skills. Fire is characterized as destructive, so how can knowledge be for example a destructive form? Lack of knowledge in the laboratory can become more destructive when the individual does not possess necessary skills and knowledge for handling the tools and equipment. Even the individual possesses those skills there are factors that can come in a way. For example human error, when an individual is handling a solution distribution with the pipette into test tubes. These are some of the things that are present and absent in the creation of technology. Which means it is *mutable immobile*.

5.2.4. Reflexive summary of Analysis II

In the section *Analysis II* were presented two examples of object formation and enactment of various practices/situations. It was an example of data at ETHOS Lab and spectrophotometer prototype at Labitat & Biologigaragen.

Both data and spectrophotometer were focused on how to understand the reality of living laboratory. The reality is understood through objects that are enacted in different practices. These objects can change their shape or movement in these practices and network in which they circulate.

The second part of the analysis was used as an attempt to apply multiplicity to practices in the living laboratory. The laboratory is seen as an organism, which is made out of multiple realities and practices, where objects are handled and manipulated. The *Living Lab ontology II* offers a different way how we can understand living laboratory. This way of understanding requires participation in the daily activities and helps to understand tensions and challenges that certain lab has. The purpose of *Analysis II* is to show how complex development of technology is. To develop something requires a different set of knowledge that is used in various practices/situations. This was shown on the example of spectrophotometer prototype development that is located in different practices. What living laboratory does better compare to traditional R&D departments is they condense the whole hinterland of a company to a small scale where it works more efficiently. In this condensed space people who are developing of technology or knowledge whatever the purpose of it is aimed at can reflect and act much faster, efficient and have an overview and access to knowledge from different practices. Therefore, the development and production of knowledge and technology in living lab is more efficient, whether one is developing an LED installation that will be a decoration on the wall in the living room or spectrophotometer prototype that will enable mobility and functionality outside of lab for researchers. And that is one of the reasons why it attracts so many investors and companies in recent years that are locked in departments and have difficulties to collaborate.

6. Discussion

In the introduction and *Living Lab ontology I* was introduced the phenomenon of living lab with the aim to cover opportunities and deficits and present overview about this wonder based on the available literature. This literature review offered a certain view on living laboratory out of which were formed dimensions that were explored in the fieldwork in two cases. Some of the tensions and challenges in the literature review were found under-extensive and therefore became dimensions to be explored.

In the *Living Lab ontology II* were introduced some of the methodologies that aimed to grasp the reality (hinterland) of living labs, where different practices tend to produce different realities that are multiple and enacted. In those practices are multiple objects that can be located in different spatialities. The aspect of *Living Lab ontology II* became more theory informed ethnography, which was based on the literature from STS studies and scholars that were at the rise of actor-network theory and those who contributed over the years and helped to shape it to what it looks like today. Scholars with various backgrounds such as philosophy entered the practices of ethnography intend to tell stories about practices in new ways. New interdisciplinary studies such as Techno-anthropology combine various disciplines like philosophy and ethics, empirical studies and practices, design and innovation. By a combination of these approaches in the case studies, the reality of these cases is being bridged and made sense out of it. The approach is not solely application of methods from one discipline and deriving understanding. It is a combination of multiple ontologies to understand complex realities. That is an attempt of *Living Lab ontology I*, and *Living Lab ontology II*, to understand practices of living laboratory. In *Living Lab ontology I* is the practice of living lab understood through dimensions that shape and define it. Living lab is understood as hinterland in *Living Lab ontology II* in which objects/knowledge are enacted in practices/situations. And where objects can be located in different spatialities. By a combination of these two approaches, we get a richer understanding of the phenomenon living lab.

The first section of *Analysis I* explored digital methods through which data are collected and analyzed. The map of living laboratories in *Figure 4* is based on laboratories website's data that were collected and clustered to create meaning. The *Figure 8-9* represents laboratory social media sites and their activity. This first section of *Analysis I* shows a hint how post-demographic methods could contribute to research, where qualitative and quantitative methods are combined. However, this part to be more extensive in this thesis would require a bigger number of data to derive from and scope of research. Therefore, for the purpose as a showcase and supplementary methods is good as it is. In second the section of *Analysis I* are analyzed laboratory's cases of study based on chosen dimensions. Based on the *Table 3* where living lab's cases were summed up is proposed a generic dimensions' version where findings from *Analysis I* are united to create a generic understanding of living labs in *Table 4*.

Living Labs' generic dimensions	
Definition of living lab	Living lab is a place that offers a flat structure with ease access to space, tools and equipment. It is created by the members of shared interest that allows experimentation and collaboration with different forms of social-izing. It functions as a knowledge repository that is spread throughout network to inform and educate others.
Self-regulation	Living labs can regulate themselves by annual, monthly or weekly meetings or set of rules they create with usage of scrum boards.
Reality of resources	The lab gets funding and resources from its members' common budget, or various donations. When lab is affiliated with university, the funding and resources are provided by the educational institution.Lab offers a wide set of tools and equipment affiliated to the lab with space and knowledge sharing repository.
Ideal of access	One of the characteristics of living labs is the openness and access to tools, equipment, space, software, knowledge and other stuff in return for small membership fee. Some universities can however be a slightly close towards the public.
Freedom	The level of freedom or in other words the power or right to carry out activities, research and act freely is in living lab is non-regulated or semi-regulated. Laboratories who depend on the university are generally afected by the hierarchical structure.
Sustainability	The awareness of the impact on the environment is very individual at each facility. Some may have more progressive attitude and others get by only by being aware.

Table 4. Comprehensive view of Living lab's dimensions

Explored living labs in Copenhagen have things in common as shown in *Table* 4. Yet, they can have differences between each other in terms of purpose, aims and other things that make them different and stand out among other labs. They are same, yet different.

The dimensions in *Table 4* are derived from cases where fieldwork took place. Definition of living lab attempts to define and expound living laboratory in general view. Some of the living labs such Labitat and Biologigaragen regulate themselves by having a set of rules that are unofficially written. Further, they manage and govern themselves through meetings that are either annual, monthly, weekly or by the request. ETHOS Lab regulates itself by weekly meetings and Scrum boards. Self-regulation is also very individual in living labs and even laboratories with the flat structure, and semi-anarchistic functionality such as Labitat requires some regulation. The resources each living lab offers are based on the community of interest that surrounds and makes the lab. The interest of the community in a particular field is a reason for using, building and having the particular technology. For example, in Labitat is halfway finished laser cutter, which needs the interest and drive of members to finish it. Therefore different laboratories have different tools and equipment that is derived from their interest. Members also share finances to afford tools, equipment, and space.

Labitat and Biologigaragen offer an incredibly open and welcoming environment. That is one of the drives for people to come. There is no age limit the members can vary from students, hobbyist, and researchers to retired people. The openness can vary among labs where some of them have more strict entry rules that do not allow everyone.

The nature of freedom in living laboratories in terms of activities and research is non-regulated and semi-regulated. Labs at the universities tend to be semi-regulated, where they are required to deliver some results in academic/political currency. On the other hand, they do not require membership fees. Labs such as Labitat and Biologigaragen are non-regulated, but require membership fees for their continuous existence.

Sustainability is not a category that necessarily defines living lab. However, this issue was not fully explored and needs further attention in the future as it is assumed that this category might play an important role. Not inevitably relating to environmental impact, but as a smart technology innovation that not once rose from living lab.

To recall things that did not work in the fieldwork or were hard to access is difficult. The almost non-existence of boundaries in labs made it very easy to access people, space, tools and knowledge. The mindset of people is to help and collaborate. If one wishes to stay in isolation and work on a project, he/she is allowed to do so.

The aspect of commercial greed for success could disrupt the nature of semi-isolation where one is allowed to work and access to surrounding knowledge. This is not such an issue in the case of Labitat and ETHOS Lab that are more exploration and knowledge repository driven compared to Biologigaragen, which belongs to biohacking community where the setting is more competitive. Binding agreement supposes to bring fairness into biohacking community to prevent the environment become hostile so that open pool of knowledge could sustain. This is however an issue of laboratories that operates on a higher level such as Waag Society in Amsterdam. (Interviewee nr.3 at Labitat & Biologigaragen) Small labs such as Biologigaragen and Labitat are more exploration technology driven, with small project orientation. Therefore, there is no need to implement this agreement to this particular places. In *Table 4,* were excluded Categorization and Purpose of living lab. Both dimensions are very individual and vary from lab to lab.

In *Analysis II,* the purpose was to apply methods and thinking from *Living Lab ontology II* into the practice. It was shown on two examples, *Data as enacted object in multiple realities* and *Absorbance measurement*. It was an attempt to show how reality in the living lab can be understood through objects/knowledge that is enacted in practices. To apply multiplicity and spatialities onto practices required being familiar with the daily activities of living labs. For this data from interviews and diary were used to understand the hinterland of living laboratories.

The implication of data as enacted object in multiple realities was to show how meaning can be created by manipulation of data and how it helps the learning process. It contributes to digital methods tools development and learning processes of lab's members. Data were a good example of fluid spatiality by changing its shape while being transported in the network. The implication of absorbance measurement that spectrophotometer prototype is part of was to show particular technology development in the practices of living laboratory.

Description of various practices/situations that spectrophotometer is part of helped to portray the hinterland of living lab that is made up of multiple realities and practices where object/knowledge is handled and manipulated. *Figure 29* portrays various situational practices.

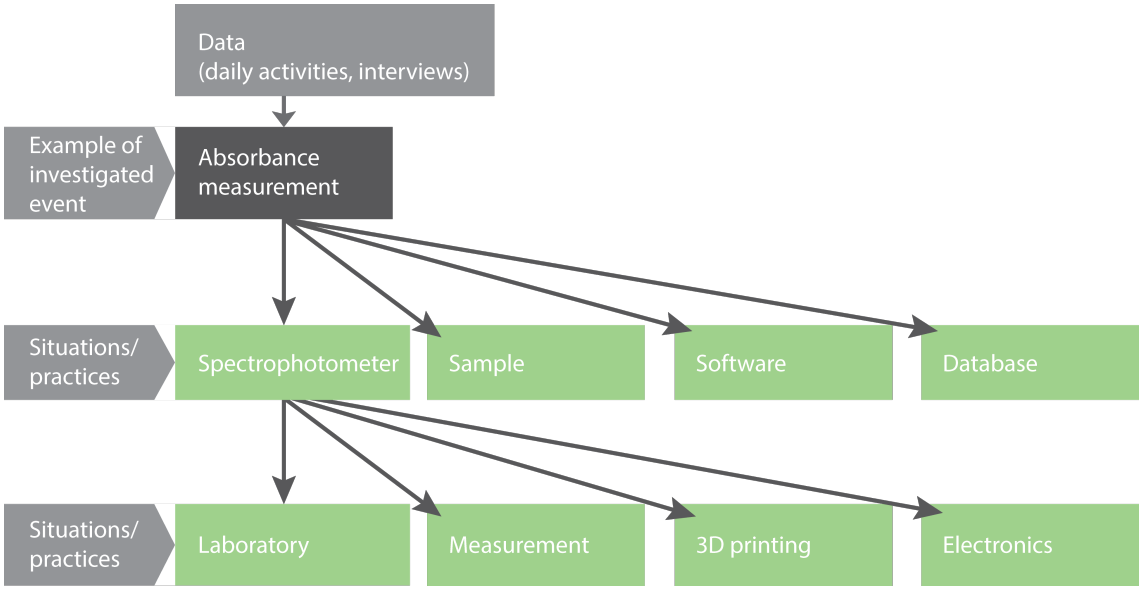


Figure 29. Comprehensive view of living lab's object/knowledge enactment in situational practices

The various practices shown in *Figure 29* are proof of living lab being a complex organism. The application of multiplicity and spatialities is difficult to study and to demonstrate. However, the *Analysis I* and *Analysis II* complement each other. The *Analysis I* offers a set of dimensions that help to define lab. What is the living lab, what they do, how they do it, what they offer, what can I do there and so forth. And *Analysis II* shows the example of technology development how they use, handle and manipulate the resources (equipment, tools, space, knowledge) in practices. We get the richer understanding of what the living lab is by combining dimensions and set them into practices, richer understanding through the example. They are same as *Table 4* shows, yet different in practices.

The strength of living lab is in the condensed space, in the collaboration effort, in the quick access to knowledge, tools, equipment, and space. Where is no formal restriction, code or etiquette. It is the ability to reflect and act in the short span of time.

We get a richer understanding of living labs by knowing what living labs are, how they function, what are their strengths and weaknesses (resources, access, freedom) and that there are different types of labs based on the communities of interest. The explored dimensions and practices help to navigate in the complexity of living labs.

7. Conclusion

As it was discussed the thesis explored the phenomenon living lab/city lab in two Copenhagen's spaces through involvement in daily activities applying ethnographic methods. The first research question was to explore the daily practices of two living labs in which was seek how living labs work with tensions between their ideals of engagement, openness to information and at the same time mobilizing resources to 'pay the rent' and invest in necessary technology they seek. And second research question was to explore how objects in the living labs are formed, and how they are enacted in different situations/practices that can be located in different spatialities.

In accordance with first research question a set of dimensions was created in order to understand what is the living lab according to lab's members, what is their purpose, how they regulate themselves, what is the reality of resources, what is the ideal of access, what is the level of freedom and sustainability and lastly to what category they fit in. Based on the finding from two cases the definition of the living lab is a place that offers a flat structure with ease access to space, tools, and equipment. It is created by the members of shared interest that allows experimentation and collaboration with different forms of socializing. It functions as a knowledge repository that is spread throughout the network to inform and educate others. Among dimension it was aimed to discover possible tensions and challenges the living labs might have. Some of these tensions are in relation to exploitation, patents and rent payments. In fulfillment of second research question the object formation and enactment in different practices was demonstrated on the example of technology and knowledge development. Through the example of data at ETHOS Lab was shown how data as an object enact in the practices and by changing shape and transport in the network create new knowledge. The second example was demonstrated on the event called absorbance measurement that for it to come into being several practices has to come together. An object spectrophotometer prototype was an example that is enacted in various situational practices that each required different knowledge and expertise. The findings contribute to the understanding of living labs by extension of studied dimensions and in-depth practices exploration.

Further explorations of living labs could involve the application of such broader set of dimensions on a more extensive number of spaces to be able to contribute for better categorization. Future research could also involve more large-scale application of digital methods as post-demographics gain more importance. And lastly, further research could focus on the in-depth exploration of chosen dimensions and practices regarding related tensions and challenges in living labs and how to solve them.

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