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Co-designing recycling solutions on campus

A case study exploring openness, realism and empowerment of users in a Living Lab

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The Living Lab concept is often distinguished from other user-centered and co-innovation approaches by an aspiration to adhere to principles of openness and empowerment of users, with a focus on innovating ideas that are realistic to the real needs of end-users. However, when it comes to implementing a living lab approach it is sometimes unclear how to put these principles into practice. In this case study, we introduce a framework for mapping three living lab principles to co-design stages within a single co-design framework and describe its use in innovating solutions for solid waste management on a university campus as a pre-cursor to scaling up the approach across the city. We present an evaluation of the framework in use against evidence of adherence to the three living lab principles of openness, empowerment of users, and realism. This work may act as a reference point for researchers to start exploring which concrete co-design activities have better impact in achieving living lab aims.

CCS CONCEPTS

Additional Keywords and Phrases: Living Lab, co-design, solid waste management, recycling, university campus, openness, realism, empowerment

1 Introduction

A living lab is a user-centric open innovation approach where users are involved in designing and developing a product. Instead of setting limitations on people's involvement, this approach invites them to actively take part, as equals in different stages of the design process. Participation may take place over a while and through different methods. The goal is to solve issues, generate ideas along with users, and test the generated ideas in their real life, thus being more responsive to users' real needs than more top-down design processes. In essence, the practices of a living lab are related to direct and indirect collaboration with users [1]. To make co-creation successful within a living lab approach designer need to utilize a wide range of knowledge. This includes knowledge related to:

- Facilitating long-term co-creation with users" [7], such as: setting up environments to facilitate and support collaborative innovation, often in the form of workshops; interacting and collaborating with a wide range of stakeholders; and motivating participation to innovation activities.

- How to co-design whilst practicing adherence to core values of living labs, such as realism based on the open innovation approach and the empowerment of users within the co-creation activities.

These types of knowledge are predominantly procedural knowledge often known as “know-how”. However, this “know-how” is not always shared with and amongst living lab practitioners and thus, living lab practice mostly depends on practitioners' education and experience. Yet there is little guidance on how to realize these principles in practice through co-design processes. This may make it hard to achieve a successful living lab approach for those who have not built up this knowledge over a while and through practice [6].

In this study we have extracted the core principles of living lab [5] and phases of co-design [8] via a literature review and developed a new framework that combines key principles of these two approaches. Furthermore, we validate the framework through a case study where a university in Finland was turned into a living lab and a co-design approach was used to improve the solid waste management situation of the University. Solving waste management on a large campus with many different types of people who use the facilities with differing motivations/language/cultural backgrounds is a wicked problem and co-design and living lab approaches are considered appropriate for tackling such problems. The original context for the living lab was to design a new smart waste management system, for example using IoT. However, in our case study we describe a design process that was intentionally agnostic to the type of solution being developed and whilst inviting technology-based solutions allowed all ideas to be proposed.

2 Development of a conceptual framework based on the principles of Living lab & Co-design

Nowadays designers are facing complex design problems. Co-design is a design process where participants from different mindsets and backgrounds are involved. It is distinguished from other types of participatory design process through the act of designing with users, rather than for them. Co-design typically progresses through a number of stages which [8] define as:

- **Pre-design phase:** exploring and understanding the problem, often by learning current experiences of users.
- **Generative phase:** a co-design phase of ideating solutions, often with the support of toolkits.
- **Evaluative phase:** evaluating proposed solutions.
- **Post design phase:** completion activities, which can include understanding how people use a finished product, sometimes leading to new design activities.

Co-design as a concept is supported by a wide array of validated practical tools and methods that support co-design practitioners in different stages of design.

Living labs are defined as “open innovation environments in real-life settings, in which user-driven innovation is fully integrated within the co-creation process of new services, products and societal infrastructures” [4]. All over Europe, living lab is now an umbrella concept for multiple sets of innovation that aim to produce solutions that are responsive to and closely fit to the needs of the users [3]. Co-design is an integral part of a living lab, but whereas the core of the co-design philosophy is based around the principle of designing with users, the living lab approach integrates three further key principles [5]. These are:

- **Openness:** the innovation process should be as open as possible, bringing a diversity of perspectives and enough power to achieve progress quickly. People should be able to join, no matter what their backgrounds are.
- **Realism:** the results should be compatible for the real markets, so it is mandatory to encourage genuine situations and behavior as much as possible. Realism is important also because focusing on actual users in real life situations distinguishes living lab from other co-creation environments.
- **Empowerment of users:** Engaging users in the design process is fundamental for innovating ideas in a preferred direction depending on the desires and needs of the users. Effectiveness of Living Labs depends on participants/users' creative ideas. So, this is very important to increase the motivation of the users so that they engage in the process.

Of these, the principle that most distinguishes living lab from other co-creation approaches is that of realism, which [5] identify as also being the hardest to achieve. They point to the need to gather more knowledge in this area as well as to understand better how the three principles are related.

One issue is that living lab is a relatively new research area. Therefore, unlike co-design the number of theories that support understanding the concept is very low [2]. The situation is the same when we are talking about methodologies, methods, and tools. This points to a need to create a wider range of concrete tools and methods from which to draw when trying to implement living labs and when aiming to meet these core principles.

In this case study paper, we introduce a framework that integrates the living lab principles of [5] to different co-design stages of [8] to demonstrate how existing co-design methods and tools may be used to support living lab principles. We then describe one instantiation of this framework and evaluate it against the core living lab principles of openness, empowerment of users and realism.

2.1 A conceptual framework based on the principles of Living lab & Co-design

The proposed framework is illustrated in Figure 1. All three principles are present in four co-design phases. The framework indicates that openness should already be considered when defining activities for the pre-design stage. As such, it is important to choose activities at this stage that are already inviting multiple perspectives to the problem and which will inform the design of actual co-design activities in the generative phase. Next, it is during this generative phase that empowerment of users starts to occur, as different stakeholders are invited into the creative process. From the framework we can see that openness is decreasing from pre-design phase to post design phase and empowerment of user is increasing from pre-design to post design phase. Finally, although it is intended that the entire co-design process itself will produce realistic outputs, realism can best be validated by designing with a view to evaluating outcomes in the wild. All of these considerations will have an impact on which co-design methods are chosen and how the process is structured.

3 Case study

In our case study we turned LUT university in Finland into a Living lab and performed a co-design approach to improve the solid waste management situation inside the university. Solid waste management in this scenario refers to the recycling of non-food waste on the university campus including paper waste, food packaging and

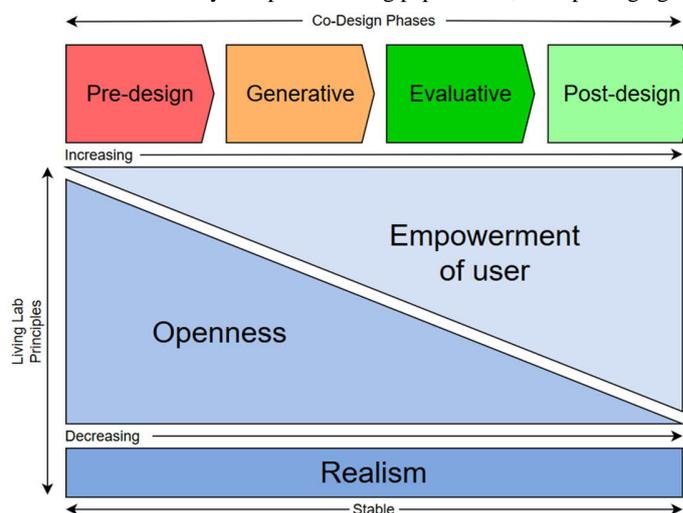


Figure 1: Conceptual framework based on the principles of Living lab & Co-design

coffee cups, and drink cans. We have different waste bins for different kinds of waste in our campus but not everyone is using the proper bin. So, the focus of this study was selective sorting and how it can be improved. We followed the new framework throughout the whole process. We designed our research steps (see Figure 2) by reflecting on the co-design approaches - which comprised the four phases of pre-design generative, evaluative phase and post design – in the context of the three living lab principles. All these phases are interdependent. The study lasted for six months.

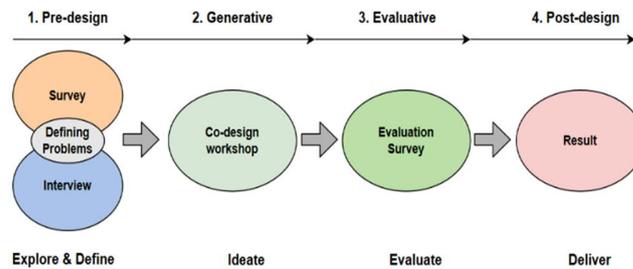


Figure 2: Research steps

3.1 Survey

To learn public awareness about solid waste management and get precise knowledge on common waste management behavior of an individual, we conducted an online survey regarding the issues related to waste recycling inside the university campus. As we were using the LUT campus as a living lab, all the participants were LUT students and staff. The survey occurred in March 2020. Several methods were used to approach the participants. Firstly, the link of the survey was sent through personal email to all known persons who study or work at LUT, with proper introduction and details of the survey. Secondly, the link to the survey and proper description was published in the university intranet. Lastly, the invitation was posted into the international group of LUT on social media. The survey mainly targeted people who are, or were, related to the university. In total 93 participants including students and staff took part in the survey. The age of the respondents was 17-24 (26%), 25-34 (42%), 35-44 (18%), 45-64 (14%). By analyzing participant’s responses, it was confirmed that the current waste sorting methods need to be upgraded because a significant number of participants answered that they are not using proper bins. A new design may help to overcome the current situation. Responses from each participant were different. By manually clustering different responses we identified four unique user groups that we represented as user personas. Each of these user groups has some different perceptions, motivations, and frustrations.

3.2 Interview

We conducted three interviews with people from LUT based on a common set of questions that were designed and agreed amongst the research team beforehand. Participants were a newly appointed sustainability manager of the university, a person responsible for university cleaning and the university’s head of development program. A single researcher conducted all the interviews over a conference call, each of which was recorded for later analysis. Through the expert interviews we gained information about the current waste management situation of the university, the biggest challenges and what they thought could be effective to change the current waste sorting situation. To show them what students and staff were thinking about the current condition we also presented the four user group personas. This helped them to open up a bit more and discuss the issues they were facing.

3.3 Co-design workshop

The co-design workshop was set up to explore, find and create possible solutions to improve the current waste management situation. From the interviews and survey, we already identified some common issues regarding the waste

management of the university. The aim of this workshop was to find solutions which can minimize those issues. Because of COVID-19 we conducted the workshop with only 9 participants. We invited five master's student, three university staff (Junior researcher) and one restaurant owner of the university. We also planned to invite the three participants from our interview session, but it wasn't possible due to restrictions. We conducted the co-design workshop in June 2020 at LUT university. Because of COVID-19 we had to follow safety procedures and social distancing, which influenced partly the activities that were possible. The whole session was divided into the following parts:

- Conversation starters (20 mins)
- Framing the design challenge (15 mins)
- Storyboard (15 mins)
- Tour inside the university (30 mins)
- Introducing the user groups (15 mins)
- Brainstorming (30 mins)
- Peer review and feedback (30 mins)

Conversation starters. We started the event with some introduction and greetings to make the atmosphere comfortable and relaxed. We then started explaining our topic, our goal and why we were doing this workshop.

Framing the design challenge. The second activity was to frame our design challenge. We presented all issues as design questions, described what impacts we were trying to achieve and also presented some possible solutions. These solutions were based on the survey results and interviews. Framing the design challenge helped us to get off on the right foot. We also had some discussions with the participants here. Participants asked questions about the problems and our suggested solutions. This session made them open up their thoughts about the topic a little bit. We also introduced examples of existing smart solutions to support participants who may not know much about technologies for smart systems, or how to design them.

Storyboard. The third activity was the storyboard. Participants encountered a short story of a student who's trying to dump his waste in the recycle bins. The scenario showed what type of difficulties the student faces while selecting the correct bin for a waste.

Tour inside the university. This session was basically a competition among the participants. There were nine participants and we divided them into three groups. Groups were formed beforehand according to participant's education background. For example, we put a participant whose background is IT in every group, other participants were from a different background. This type of diverse group can help to develop different ideas. This grouping was maintained throughout the rest of the co-design session. The objective of the game was to find different bin location inside the campus, identify some problems with that recycling point and at finally take a selfie at that recycling point with all the group members. The main idea was to let the participants find different recycling points and identify the issues of that point by themselves. We also assigned points for different tasks. Finding a bin location is 3 points, each identified problem gave them 1 point and taking a selfie with all group members is 1 point. At the end, the team with maximum points won the competition. This competition was a part of problem identification process.

Introducing the user group. To help the participants think more deeply about the problems, we presented the personas of the four user groups that we created based on our survey results. We asked all the participants to study the personas and find which persona was closest to their personality (Figure 3, left).

Brainstorming. This was the most important part of the workshop. In this session participants worked as a group and ideated some solutions (Figure 3, middle). We maintained the same groups as during the competition. Each group was given a task to think about the problems they had encountered so far and create a design of a solution which could help. Related to the previous task, each of the participants had also chosen one persona which reflected their own behavior and tried to make solutions for that persona's frustration. As all the personas had different and multiple frustrations one solution couldn't help everyone. That's why participants came with multiple solutions.

Peer review and feedback. This was the last session of the workshop. After finishing the brainstorming session one member from each group came and gave a short speech about their project. Participants used papers, pencils, colorful pen, and other necessary stuffs to sketch and write down their ideas (Figure 3, right). They explained why they choose that solution and what kind of benefits were possible from that solution. After presenting the solution, members from other groups delivered their comments and feedback about the solutions.

4 Results

As we found multiple different solutions from the workshop participants, selecting just one idea from them was not a good decision. Also just implementing one change will not solve the present waste sorting situation. According to the conversations we had with the interviewees we found that several things could potentially



Figure 3: Co-design activities

improve the solid waste management situation. Finding a completely new solution is not the only option. Implementing a small change in the current system could also lead to big improvements on the current situation. For example: adding different types of recycle bins, proper labeling on the bins, changing the location and placements of the bins. Taking these issues into account we decided to categorize the solutions into different solution types and collect feedback on them through a follow up evaluation survey that went out to staff and students in the university. The survey respondents were asked to choose both their favorite type of solution as well as the best idea within that solution type. 36 people responded to this second survey, which was performed in July 2020 which is a common vacation month and therefore the number of respondents was lower. Among the participants 44% were staff members, 3% were bachelor students, 33% were master's students, 14% were doctoral students and 6% were other people related to the university. The solution types and different solutions are shown in Table 1.

Table 1: Proposed solutions from the workshop

Solution Type	Proposed solutions
Implementing a new system	KIOSK (Digital display) Smart recycling points
Implementing a change	Smart recycle bins which will give feedback Biodegradable coffee cups Bin sequence Change bin location Every building should have every type of bin A map Footstep direction Reusable cups with LUT logo
Attachment to the current system	Put popular waste image in recycle bins Different symbols and colors in waste and waste bins Increase the amount of commonly used bins
Raising awareness	Tutors can show students different recycling points Introducing short courses Task in orientation week regarding waste sorting Organize workshop or teaching events for new students

The favorite solutions based on the result of the evaluation survey were:

- **Implementing a new system:** A smart waste bin which will give feedback. Students will know if they are making mistakes. Sooner or later they will learn from feedback.
- **Implementing a change:** Introduce biodegradable coffee cups to reduce paper and plastic waste.
- **Attachment to the current system:** Visual images of the most common wastes on the recycle bins to identify what kind of waste they have and which bin they should use without confusion.
- **Raising awareness:** Arranging programs for the new students where they will learn about waste problem and how to sort it properly before dumping.

5 Reflection on key principles of the framework in case study

In this section we will explain how the new framework helped in our research process. As mentioned earlier the framework is based on three principles of Living lab (Openness, Empowerment of User, Realism) and four stages of Co-design (Pre-design phase, Generative phase, Evaluative phase & Post-design phase).

5.1 Openness

The first principle, openness, in a living lab highlights that the innovation process should be as open as possible. It's a foundation of the process user-driven innovation. Openness invites multiple perspectives to bring power in the development process. The pre-design phase of co-design is all about people's experiences. Researchers during this phase can gain a clear view of public experience. Reason why openness is in the peak level during this phase. In our case, we performed a survey among staff and students to find out their experiences, thoughts, frustrations, and expectations towards the current waste management system. The survey was made to be as open as possible and invite different perspectives. These were then curated into four user personas that represented this data and essentially allowed the voices of 93 others to be heard in later stages of co-design, even when they could not be present. This was especially important as COVID restricted numbers allowed in co-design. This approach demonstrates one way to achieve a measure of openness in a living lab.

5.2 Empowerment of users

The second phase of co-design is the generative phase. In this phase, new design opportunities are ideated. In our case, we performed a co-design workshop inside the campus with students and staff from different backgrounds. Together they generated several solution ideas about the current waste management situation by participating in games and different events that were arranged during the workshop. The second principle of living lab starts to reflect mostly from this phase. Empowerment is defined as a person's capacity to make effective choices; that is, as the capacity to transform choices into desired actions and outcomes. The extent or degree to which a person is empowered is influenced by personal agency (the capacity to make purposeful choice) and opportunity structure (the institutional context in which the choice is made) [9]. Generative phase reflects both on openness and empowerment of user. In the co-design session, participants had freedom of making choices. That's why the result was many different types of solutions, not just some stereotypical solutions, or even technology-based solutions which were the original intention. The key point of the principal of empowerment of users and openness in living lab is to make inventions based on human needs and to use the creativity of users, which was perfectly visible in this phase. The third phase of co-design is the evaluative phase. At this point, design decisions are already made and now it's time to verify the ideas by using prototypes or evaluation. The main idea of the evaluative phase is to evaluate the ideas with the help of real people and then implement the idea in post design phase to gather public reaction. Here user has the power to choose what type of solution they would like to see. Empowerment of user is in the peak level in these two phases. Because of the COVID-19 situation, making prototypes and monitoring user reactions was not possible, so instead we conducted a further survey to evaluate our findings from the generative phase.

5.3 Realism

Realism is the principle which separates Living lab from other systems. It highlights the importance of using real situations and behaviors to generate results which are valid for real markets. As the goal of co-design process is to make a realistic solution, realism is stable in all the co-design phases since all the steps we took was with real users. We did survey with people who were going to be affected by the result, interviewed people who are responsible and managing the issue, did co-design with people from different roles. But in terms of assessing realism it is important to note that many of the proposed solutions could have been implemented and tested quite easily in the post design phase: they were not outside the bounds of possibility. Also, through the evaluation survey it was clear that many of the solutions were popular even with those outside the initial co-design team of 9. The full process of our research is illustrated in Figure 4.

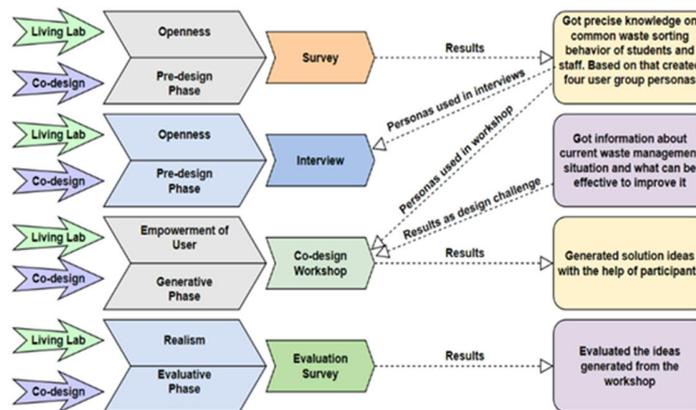


Figure 4: Research steps by merging living lab and co-design

6 Limitations

Our case study was related to the university and our goal was to improve the waste management situation inside the university. During the time of the research, the university was closed due to Covid-19 restrictions and only small number of people could be recruited which limited the data we could collect and the conclusions which could be drawn from them. The post design phase where prototype ideas should be implemented for monitoring user reactions was not accomplished through this case study, also due to COVID. It was therefore not possible to fully assess the outcomes in terms of realism, nor was it possible to have a fully open design process.

7 Conclusion

In this work we presented our experience from a living lab and co-design study with university students and staff in the context of finding solutions of a wicked problem which is solving solid waste management issue of a university. We have demonstrated that giving clearer consideration to how living lab principles and co-design activities work together may lead to better possibilities for evaluating whether living lab principles have been achieved. Based on literature there is no general methodology on how to involve users in living lab. Openness is one of the core principles of living lab, but very few studies succeed to reflect on it. Co-creation or empowerment of users is another essential characteristic of living lab but most of the time living labs do not support true user innovation [6]. Our aim was to show how living lab and co-design can be achieved at the same time and reflect the principles of living lab in each co-design stages by using the framework. We identified different phenomena and challenges from our experience of dealing with users in a real world context and offer some ideas for how to measure such successes, using our solid waste management living lab as a case study. We tried to keep the design process as open as possible and ensured empowerment of users. From our experience we noticed that it created a major impact on our outcome. The initial goal of this case study was to innovate an IoT-based design solution. In choosing to be agnostic to the type of solution being sought, we got a mix of both technology and non-technology-based solutions and this demonstrates that it cannot always be assumed that tech will be the answer.

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