Make way for the new wave: Living Labs as a Design Science Research Approach

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Abstract. Living Lab (LL) has been used as a milieu as well as methodology for open innovation. However, the impression of LL as a research methodology among academia is still blurring. The LL carries many elements of design science research paradigm such as innovation, artifact, evaluation, design principles, etc. however it still needs conceptual underpinning to proclaim it as a valid Design Science Research (DSR) methodology. The peculiarity of the LL approach compare to existing DSR methodologies is its openness, co-creation, and evaluation of IT artifacts beyond organizational context. With the continual growth of open innovation platforms, the LL as a DSR methodology can play a supplementary role along with its other companion such as design science, action research, and action design research. In this regard, this paper will provide a conceptual clarity in establishing the LL as a DSR methodology in the context of open innovation and co-creation of IT artifact that goes beyond organizational setup.

Keywords: Living Lab (LL), Design Science Research (DSR), methodology

1 Introduction

Living lab (LL) has been created to involve real users in real life environment where users together with researchers, companies and public institutions work together in the development of new solutions, new
products, new services or new business models (John Krogstie, 2012). LL is an exemplar of “the growing interest in conceptualizing the artifact in socio-technical terms, where the artifact is regarded not only as a stand-alone piece of technology, but also as something that is significantly interwoven with organizational and social elements and related logics” (Rossi et al., 2013). LL is based on principles such as: openness, innovation, sustainability, realism and co-creation with knowledge production (Bergvall-Kåreborn & Ståhlbröst, 2009). To this background, LL has been defined as an environment, as a methodology, and as a system (Almirall & Wareham, 2011).

While the literature is rich on studies strongly emphasizing LLs as milieus for open innovation (Følstad, 2008), a few attempts have been made to identify the common elements between Design Science Research (DSR) methodologies and LL (e.g. John Krogstie, 2012). Both DSR and LL are based on the common philosophy of design, innovation and use of artifacts. Like DSR, LL approaches are multidisciplinary by nature; it involves various stakeholders in designing, building and intervention of artifacts, and follows iterative process. But the interesting point is DSR researchers are trying to root their theory on practice, whereas, LL researchers are trying to find theoretical underpinnings for their practice. Likewise, in contrast to DSR, where researchers justify design with a rigorous and well-defined theoretical agenda, LL researchers seek to articulate novel and innovative use patterns of ICT based on end-user knowledge and interaction (John Krogstie, 2012). LL incorporates many of the elements found in the DSR paradigm, such as innovation, artifact-focus, evaluation, design principles, etc., but there is a lack of theoretical underpinning to declare it as a valid DSR methodology. To this end, we see these two approaches can be a good companion. However, the question arises in what ways LL can be a DSR methodology, and what new perspectives will it bring to the DSR community?

To answer the research questions, we re-interpreted two previously published cases on LL approach. Our particular interest in this paper is to argue that LL can be a subset of the DSR approach. We draw our arguments on the strategic dimensions of DSR provided by Iivari (2014). The study contributes to the DSR community by providing new perspectives from LL approach, at the same time, contributes also to the LL community by positioning LL to the well-established DSR domain.
The rest of the paper is organized as follows. Section 2 introduces Living Lab. Section 3 describes the similarities and differences between DSR and LL in light of Ilivari’s (2014) DSR strategic dimensions. Section 4 re-interprets two LL projects from DSR perspectives. Finally, section 5 concludes with the discussion.

2 Living Lab Innovation Process

The concept of LL started to emerge in the late 1990s and the beginning of the 2000s, and the focus was initially to test new technologies in homelike constructed environments (Markopoulos & Rauterberg, 2000). Since then, the concept has grown and alter a bit in perspective and now, one precondition in LL activities is that the innovation processes are situated in real-world contexts (Almirall & Wareham, 2011; Dutilleul et al., 2010). Today, there are more than 350 LLs around the world who are part of the European Network of LLs. The LLs are active in developing innovations in a diversity of areas such as, eHealth, eManufacturing, energy, smart cities, and gaming. Common characteristics among these LLs are (J Krogstie et al., 2013):

- To carry out exploratory need studies with voluntary contributors (Ståhlbröst & Bergvall-Kåreborn, 2013)
- To provide insights into unexpected ICT uses and opportunities for new service
- To evaluate new ICT-solutions with users
- To test and experiment with ICT solutions in real world contexts
- To conduct medium or long-term usage studies involving relevant stakeholders

The important aspects of LLs are exploration, experimentation and also co-creation with real users in real life environments. In these processes, users, together with researchers, companies and public institutions work together in the development of new solutions, new products, new services or new business models. The foundation of LL is based on five key principles (Ståhlbröst, 2012):
• **Value**: LL processes should support value creation in preferably two different ways: for their partners in terms of business value and for the presumptive customer, or user, of the developed innovation in terms of user value.

• **Influence**: Viewing users as active, competent partners and domain experts are vital since their involvement and influence in innovation processes is essential. To motivate participation and engagement among users, it is important to illustrate the impact of the interaction with the users has on the innovation.

• **Realism**: One of the cornerstones of LLs is activities should be carried out in a realistic, natural, real-life setting. This is important since people cannot experience anything independent of the experience they get from being embodied in the world.

• **Sustainability**: LL is defined as an approach that meets the need of the present without compromising the ability for future generations from an economic, social and ecological perspective. It is also one cornerstone for the continuous learning cycle within the LL.

• **Openness**: This principle stresses the importance of having an innovation process that supports a bidirectional flow of knowledge and resources between stakeholders (Chesbrough, 2011). The idea is that multiple perspectives bring power to the development process and contribute to the achievement of rapid progress. However, to be able to cooperate and share in a multi-stakeholder milieu, different levels of openness between stakeholders seem to be a requirement.

There are several similarities between LLs and traditional user involvement processes, such as involving users in the different phases of the process, co-creating solutions, having the user in the center of the development of innovations, doing field tests and applying a multidisciplinary approach (Ståhlbröst, 2008). What differs between LL and traditional approaches is the explicit focus on user needs; LL focuses on opportunity seeking in innovation, having sustainability as one aspect that needs to be considered both in relation to the innovation and the process. LL research is focused on service innovation specifically
where the innovation process is supported by ICT technology. In the subsequent section, we embark on the initial comparison between DSR and LLs.

3 DSR and Living Lab: similarities and differences

This section aims to provide a structured comparison between DSR and LL methodology in the light of Iivari’s (2014) proposed strategies for DSR. Two strategies were proposed by Iivari as a mean to clarify some conceptual confusion of the DSR discourse. The central argument is that DSR is research with design as a method of investigation and DR is broader, with design as a method of investigation and a topic of investigation (ibid., p. 2). The controversy Iivari addresses lies in the distinction between designing meta-artefacts and designing instances with specific client contexts. Iivari take the stance that the strategies he proposes are in line with traditional constructive view on DSR. Others have argued, e.g. Sein et al. (2011) that methods should both recognize the emergence of IT-artefacts in context and the researcher’s initial intent with the design. To that end, our objective here is to show that the LL approach carries DSR features, but doesn’t instil itself to particular strategy type or method and possibly also other specific DSR approaches, but overlaps with both the strategies. Iivari (2007) organized detailed strategic dimensions using Denison et al.’s (1996) framework of context-process-outcome dimensions. We discuss also the component of control because design decisions are made on to what extent the object of study is controllable (Rossi et al., 2013). The comparison is presented below.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>A client may be involved, but not necessarily</td>
<td>Client involvement is inevitable</td>
<td>LL- focuses on real world interaction and implementation of the innovation starting</td>
</tr>
</tbody>
</table>
from early ideas and mock-ups to fully functioning prototype. No overlap

The LL design process is by character not as rigorous as, for example the design science (DS) approach suggested by Hevner et al. (2004), which assumes that the research problem is defined by researchers focusing on the knowledge gap found in the literature. This is not a typical stance in LL research, as the research problem can emerge in manners independent of primary researcher. The LL principle of realism corresponds to this dimension, which strongly emphasize that design should be carried out in settings where people can capitalize on their own knowledge. This principle is thus similar to, e.g. reciprocal shaping, which is a key principle in the Action Design Research (ADR) method.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Major problems to be addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy 1 - Context</td>
<td>1. A specific problem encountered by a client</td>
</tr>
<tr>
<td></td>
<td>2. The general problem can emerge</td>
</tr>
<tr>
<td>Strategy 2 - Context</td>
<td>Class of problem – more or less informed by specific problem in practice</td>
</tr>
<tr>
<td></td>
<td>LL - The problem can be general (existing knowledge gap) and emerge independent of primary researcher. Overlap between strategies</td>
</tr>
</tbody>
</table>

Knowing the major problem at hand is critical to any design research methodology as it helps justifying any suggested solution. Peffers et al. (2007) argue that researchers and the audience together can better understand the reasoning associated with the researcher’s understanding of the problem. Similarly, Krogstie (2012) argues that design includes a search process within the entirety of the context to identify the relevant research problem. One central assumption in LL processes is that the innovation process should be inspired by opportunity seeking, for example what works well in a particular situation rather than focusing on solving a particular problem, which is in line with, for example, appreciative inquiry (Cooperrider & Whitney, 2005; Norum, 2001). This basic assumption gives opportunities for a fruitful ideation stage. The ideas are thereafter developed and designed into different types of artifacts, which then can be evaluated and re-designed in iterative cycles with its users and other stakeholders until a final artifact is ready.
**Dimension artifact built**

<table>
<thead>
<tr>
<th>Strategy 1 - Outcomes</th>
<th>Strategy 2 - Outcomes</th>
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</thead>
<tbody>
<tr>
<td>1. Conceptual IT meta-artefact as a DSR contribution</td>
<td>1. A real system implementation as a specific solution to a problem encountered in practice</td>
</tr>
<tr>
<td>2. Possibly a real system implementation (instantiation) of the conceptual IT meta-artefact</td>
<td>2. Conceptual IT meta-artefact as a DSR contribution</td>
</tr>
<tr>
<td>3. Possibly a real system implementation (instantiation) of the conceptual IT meta-artefact</td>
<td>3. Possibly a real system implementation (instantiation) of the conceptual IT meta-artefact</td>
</tr>
</tbody>
</table>

**LL**. Both DSR and LL produce viable artifacts in the form of a construct, a model, a method, or an instantiation. Overlap between strategies

The LL principle sustainability indicates the necessity of artifacts addressing the research problem without jeopardizing the ability to meet future changes in requirements, domains, environments, etc. Rossi et al. (2013) argue that problem spaces changes over time and that any artifact also must change accordingly. According to the authors, it is critical that designers should be attentive to multiple design paths (p.5).

**Dimension Primary role of the real system implementation**

<table>
<thead>
<tr>
<th>Strategy 1 - Outcomes</th>
<th>Strategy 2 - Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantiation as a proof of concept and possibly used in the evaluation</td>
<td>The real system as a specific solution to a problem encountered in practice implemented primarily as a source of inspiration. Instantiation as a proof of concept and possibly used in the evaluation</td>
</tr>
</tbody>
</table>

**LL**. Overlapping between the strategies as proof of concepts are introduced.

In line with the two strategies Harnesk and Thapa (2013), write that the LL is a design domain where researchers outline a meta-artefact upon which an instance is released to a crowd for empirical test and evaluation purposes. A typical approach proving the success of concepts is (a) classification and systematization of the instantiation, and (b) formalization. The purpose with classification is to create a class model that explains how the pre-defined problem should be solved. Systematization activities include specification of conditions controlling the events of the artifact and the variables that affect the artifact in use. Formalization is an approach for developing a conceptual scheme drawing on the consensus of the research team that further lead way into implementation activities. On the other hand, the LL audiences anticipate to be inspired by the innovative artifact and seek new busi-
ness value in processes and communities where innovation substantially can differentiate from e.g. business competitors.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Typical nature of the IT meta-artefact</th>
</tr>
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<tbody>
<tr>
<td><strong>Strategy 1 - Outcomes</strong></td>
<td><strong>Strategy 2 - Outcomes</strong></td>
</tr>
<tr>
<td>A new, innovative concept for a software - hardware system or a new innovative systems development approach, method, technique</td>
<td>New, innovative design principles</td>
</tr>
</tbody>
</table>

LL- Overlapping between the strategies.

In contrast to DSR concepts, LL based design mixes economic and social contexts and is driven by individual and collective experimental activities (John Krogstie, 2012) also c.f. (Yoo, 2010). The uniqueness of the LL as compared to existing DSR methodologies can be found in the embodiment of properties such as openness, co-creation, and evaluation of IT-artifacts beyond the organizational context. Giving attention to design in open innovation contexts entails a shift in modes of analysis toward co-evolution of IT-artifacts where researchers seek to harvest creative ideas and work capabilities within a designated crowd community and translate these into end product (Bergvall-Kåreborn & Ståhlbröst, 2009).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Major process driver</th>
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<tr>
<td><strong>Strategy 1 - Process</strong></td>
<td><strong>Strategy 2 - Process</strong></td>
</tr>
<tr>
<td>The constructed meta-artefact as a general solution concept, if to be tested and evaluated on the field</td>
<td>Experiences from the process of addressing the specific solution to a problem encountered in practice</td>
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</table>

LL- Overlapping between the strategies.

The concept of need-finding is central to the design process utilizing LLs as pilots in IT artifact design. The concept of need-finding does not hold any assumptions that any need or preference rest latent in the LL community to be found. On the contrary, need-finding is a driver of the design process within LLs. Need-finding places emphasis on contextual knowledge in users as active, competent partners and domain experts in innovation processes is essential Need-finding relates strongly to both problem definition and establishing the relevance of the problem as well. Need-finding underpins the principle of influence in LL milieus.
While scanning through the literatures of LL, we identified some common features between LL and DSR approaches, such as innovation, co-creation and knowledge production. However, in spite of some identified overlap the overall procedure in LL is slightly different in terms of problem formulation, use of theory, and building, intervention and evaluation of IT artifact. For example in LL primary researcher does not have explicit control on the creation of artifact, though the evaluation is done in a very controlled laboratory environment. Therefore, we propose LL as a subset of DSR methodology that can have similar elements with DSR in general, though with some unique flavors. The acceptance of LL as an authentic complementary flavor to DSR will enrich the DS paradigm with an additional methodological support.

Furthermore, it is important to recognize that DSR project in practice can start from one type and ends up in other types, DSR methodologies are not mutually exclusive but complementary in nature, and the usage of LL as valid DSR methodology will provide new perspective to the DSR community. On the other hand, the LL community will find an identity in terms of defining it as a valid methodology in itself. The LL approach can provide new ways of theorizing the IT artifact, for example LL projects showed that design theory need not be always rooted on existing kernel theories, but it can emerge in a grounded manner. Likewise, the building, intervention and evaluation of IT artifact can go beyond the organizational setup.

4 Re-interpretation of LL projects with DSR perspective

In this section we are presenting two LL cases to show how the projects closely followed the DSR approach, at the same time, kept its uniqueness, such as openness, innovation and knowledge co-creation beyond organizational context. Both cases (as presented in table 1) show how the projects started with problem formulation through user involvement and went through series of iterative phases of designing, building, intervention and evaluation of the artifact in an open environment, finally, generated design principles based on the learning and reflections. The details of the cases are as follows.

The first case, EAR-IT project is an EU FP7 funded project, started in 2012 and ending in 2014, which focuses on large scale ”real-life”
experimentations of intelligent acoustics (Ståhlbröst et al., 2014). This has the objective to support high societal value applications and deliver new innovative range of services and applications mainly targeting smart-buildings and smart-cities. For example, EAR-IT intelligent acoustic solution provides “situational awareness” by using audio monitoring in combination with Internet of Things (IoT) technologies (c.f. livari’s strategic dimension Primary role of the real system implementation). This is achieved via the deployment of Audio Processing Units (APUs) in the targeted in-door and out-door environments as complementary intelligent sensors to the already available sensor modalities in a test-bed (HOBNET, ID 257466; Santander, ID 257992). An APU consists of a microphone and an embedded processing platform, which hold a software framework for audio signal pre- and post-processing, and machine learning algorithms that can be trained and used for the detection of arbitrary acoustic events and speech commands. The APU continuously “listens” to its environment and analyses the sound according to the specified use-cases locally (c.f. livari’s strategic dimension Artifact built).

From the DSR perspective, the problem formulation in this case begins when the researcher realized that the usage of IT is visible in almost all facets of citizen’s life and gives a vast amount of available data about a person (c.f. livari’s strategic dimension Major problem to be addressed). Living in the contemporary society implies that we, to some extent, give up some details in our private lives, leading to a perceived loss of privacy. This can make citizens more vulnerable and thus, the anxiety of privacy issues increases among people (e.g. Bélanger & Crossler, 2011; Hough, 2009). It is therefore important to understand how to design innovative IT-solutions that protects citizen’s privacy from the start. As stated by Hong & Thong (2013), information privacy is one of the most important issues to handle in the information age due to the increased use of digitalized information and personalization.

In this case the problem and solution space was somehow a priori, as the researcher were aware that this can be achieved via the deployment of Audio Processing Units (APUs) in the targeted in-door and out-door environments as complementary intelligent sensors to the already available sensor modalities in a test-bed (HOBNET, ID 257466; Santander, ID 257992).
After problem formulation, in the initial phase, the artifact was designed without user interaction to set up the technology and to make sure that algorithm; event triggers, etc. were fully functioning. Thereafter, iteration with citizens has been carried out which led to a redesign of the solution to make sure that no human voice was stored and could not be detected. This was the point where the project went beyond the organizational setup (c.f. Iivari’s strategic dimension Typical nature of the IT meta-artifact). The development process is designed to continuously iterate with citizens and affected and thus take their considerations into account in the design of the final set-up of the solution. The involvement of citizens has been designed as a three-stage process that started with a structured survey on information privacy in general to a broad population (c.f. Iivari’s strategic dimension Client – Researcher relationship). The second stage is to investigate citizens’ attitudes towards this type of technology in the implementations stage and the third stage is to explore their experience of being exposed to the technology over time. These cycles can be correlated to the BIE phases in ADR. Viewing the results of this study from the perspective of privacy by design, it becomes important that audio monitoring solutions do not store human voice. It is also important to consider what type of data that must be stored and what type of data that can be streamed through the system with a trigger that detects certain events. Another design aspect in audio monitoring systems is to use it in solitude; this means that the audio monitoring system should not be combined with other technologies. In this EAR-IT project Information privacy theories were taken as the kernel theory, however there are examples of LL cases where kernel theories were not considered onset. Regarding the evaluation of the IT artifact, the real world scenario was taken. For example, the product was tested in the context of streets and public buildings. The process of knowledge co-creation went through a regular interaction between citizens, employees and visitors in this setting.

In terms of differences with traditional DSR approach, the project applied an open innovation approach by inviting several stakeholders into the development of the artifact. This can for example, be envisioned in the involvement of citizens, employees and visitors in our design process (c.f. Iivari’s strategic dimension Major process driver). Also, researcher from many different fields such as audio monitoring, social informatics, computer science and privacy laws where involved in the design of the final solution. Finally, the project postulated some
design principles based on learning experiences acquired while applying the LL methodology, which were used in other LL projects.

The second case, called SITE, is a collaboration project between a university, an SME and a school (Ståhlbröst et al., 2012). This project was carried out between the year 2009 and 2012. It was focused on the design and implementation of IT-artifact through user participation with pupils and teachers at the elementary school, combined with smart technology and innovative processes, design new visualization techniques that stimulate people in the school to reduce energy consumption and raise their energy awareness. The project was a continuation from both national and international/EU projects in the field of energy consumption reduction with a focus on co-creation and participation (c.f. Iivari’s strategic dimension Major process driver).

In this research project, the problem formulation took its starting point in two different situations. Firstly, energy efficiency in public buildings and the need to understand how people working or visiting public buildings could be encouraged to save energy even though they would not benefit directly (c.f. Iivari’s strategic dimension Major problem to be addressed). Secondly, the aim was to test co-creative methods for developing the solution. Here, the challenge was to use methods that pupils appreciated and understood.

The energy monitoring system being co-designed in this project is called SABER. This system is a combination of energy measurements, visualization and counseling. The measurement system is developed to meter electricity, district heating as well as both warm and cold-water consumption in both public and private buildings. It is connected to the buildings metering system and to the Internet, which makes it possible to send data to the SABER server (c.f. Iivari’s strategic dimension Primary role of the real system implementation). The software measures the consumption, and data for the individual meter can be visualized on a screen. In this project, the metering system was installed in three different classrooms and in the school kitchen starting with collecting reference data before the visualizations where designed and installed. This project was divided into five different phases starting with installation of meters; the second phase was co-creation of the visualization together with the pupils and teachers, followed by development and installation of visualizations. The fourth phase was to evaluate the pupils and staffs experience and understanding of the installed visualizations and the final phase was the re-design of the visualization.
The visualization of the energy consumption was shown on screens installed in separate rooms (c.f. Iivari’s strategic dimension *Artifact built*). These visualizations showed both the current energy consumption in the classroom, as well as how much energy was consumed the last week and compared it to other weeks.

In the co-creation of the visualization, pupils in the school participated in a workshop in which they developed paper-based designs of how the energy consumption could be visualized to be understandable and motivating to decrease their consumption (c.f. Iivari’s strategic dimension *Client – Researcher relationship*). Then they collectively voted for the design they liked the most. Thereafter, the SME developed an energy visualization based on the winning suggestion. The pupils used the visualization for a few months’ time and then evaluated it in surveys. The pupils got an evaluation survey in which they could give their responses to their experience of the visualization; if they thought it was nice or ugly, easy or hard to understand, interesting or uninteresting, motivating or demotivating etc. In this evaluation, 48 pupils responded.

Based on the findings, five design principles were identified relating to energy information systems. 1) Catch the attention of the users with, for example, varying views, 2) Support comparisons between different consumption periods, 3) Reflect instantaneous consumption, 4) Be positive and encouraging strengthening positive behavior, 5) Small explanatory texts to increase understanding. The theories that were used as kernel theory in this case were Information design and visualization theories, as well as energy informatics.

The two cases followed the DSR approach; however, they were different in nature. For example, the problem formulation differs a bit between the projects. In SITE, the problem area was more focused on how to design a visualization of energy in public buildings, the background technology was determined beforehand. It was almost fully functioning (SABER) but the design of the visualization of the energy was co-created with pupils and developers in an iterative manner. It was designed into the process that the pupils in the school should be involved in the design of the visualization to increase their interest of energy as well as their understanding of the visualization. In this case, the project team did not know how to design a visualization that fitted into that context. Hence, being involved in the real-world situation made it possible for the project team to develop a solution that fitted into their con-
text and understanding. Furthermore, the team elaborated on LL methodologies to come up with an approach that fits into the real-world situation where younger people can be involved. This was rather demanding since youngster aged between 12-14 years do not have a high interest in energy consumption in schools. Hence, the SITE project had two problem areas, visualization of energy and involvement methodologies.

In the EAR-IT project, the theories on information privacy (and privacy in general) were used from the beginning, and in the SITE project theories on information design and visualization were applied later on as a tool for analyzing the results from the evaluations of the visualization that was finally designed. As described, in the first case theories guided the design of the artifact from the beginning of the project (here the algorithms and other technologies were developed in previous projects and taken into this project, but in the set-up in this project the theories, and the results from the user studies) guided the final set-up, and in the second case, theory guided the analysis of the evaluation results of the designed artifact. Hence, in SITE the theory did not guide the design of the artifact. However, in SITE the project team used participatory design theories and motivational theories to guide the design of the methods used in the case, and these were used in the beginning of the project.

It is also rather typical for LL studies that the objective of the studies are directed in two ways, both on the technical artifact as such (which can or cannot be guided by theory) and at the user involvement process (which is guided by theories on participatory design, field studies, usability theories, etc.), which usually gives us contributions to both methods and theories. Usually, results from LL studies come in the form of: design principles, understanding of user motivations and needs, innovative user engagement processes, the LL concept as such (management of LL, value of it, etc.) and so forth. The most important part of LL, which needs to be highlighted, is the sustainability and long-term perspective of the organization. For example, the project team is working on developing their own LL methodology (FormIT), learning from each case are brought into the methodology and can thus be applied in other cases.
<table>
<thead>
<tr>
<th>Case-1</th>
<th>Problem formulation</th>
<th>Artifact</th>
<th>Designing, Building, and Intervention</th>
<th>Evaluation</th>
<th>Design principles</th>
<th>Theory used</th>
<th>Differences between traditional DSR approach and LL DSR approach</th>
</tr>
</thead>
</table>
| The EAR-IT project | Privacy as an important aspect to take into consideration in the design of the intelligent acoustic systems. | Intelligent acoustic that provides “situational awareness” by using audio monitoring in combination with Internet of Things (IoT) technologies. | *Initial phase:* the artifact was designed without user interaction to set up the technology and to make sure that algorithms, event triggers etc. were fully functioning.  
*Second phase:* Iteration with citizens, redesign of the solution to make sure that no human voice was stored and could not be detected. The development process is designed to continuously iterate with citizens and other stakeholders. | The evaluation done in three-stages:  
First, structured survey on information privacy in general to a broad population.  
Second, investigated citizens’ attitudes towards this type of technology.  
Third, explored citizens experience of being exposed to the technology over time. | Audio monitoring solutions should not store human voice.  
Consider the type of data that should be stored, and streamed through the system with a trigger that detects certain events.  
Audio monitoring system should not be combined with other technologies. | Information privacy theories | Real world context, (implementation context):  
City context  
Public buildings  
**Stakeholders/roles** being involved and having influence by and/or having influence in the development process:  
Citizens, Employees, Visitors in public buildings  
Company, Municipality representatives  
Multi-disciplinary research team (computer science, Participatory Design, acoustics, signal processing)  
**Openness:**  
Open innovation by inviting several stakeholders into the development of the artifact. This can for example, be envisioned in the involvement of citizens, employees and visitors in the design process.  
**Sustainability:**  
Long-term commitment to innovation activities and usage of LL methodologies and tools.  
Involvement of companies that implement the technology to facilitate viability of the designed artifact. |
<table>
<thead>
<tr>
<th>Case-2</th>
<th>Problem formulation</th>
<th>Artifact</th>
<th>Designing, Building, and Intervention</th>
<th>Evaluation</th>
<th>Design principles</th>
<th>Theory used</th>
<th>Differences between traditional DSR approach and LL DSR approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>The SITE project</td>
<td>Firstly, energy efficiency in public buildings Secondly, co-creative methods for developing the solution</td>
<td>The energy visualization system, SABER</td>
<td>The development and evaluation of the visualization took place in two different iterations. First, the pupils in the school took part in a workshop. Second, the SME developed an energy visualization based on the winning suggestion, and then evaluated it in surveys.</td>
<td>The pupils got an evaluation survey in which they could give their responses to their experience of the visualization; if they thought it was nice or ugly, easy or hard to understand, interesting or uninteresting, etc. In this evaluation 48 pupils responded</td>
<td>Five design principles identified relating to energy information systems. Catch the attention of the users with for example, varying views, Support comparisons between different consumption periods, Reflect instantaneous consumption, Be positive and encouraging strengthening positive behavior, Small explanatory texts to increase understanding.</td>
<td>Information design and visualization theories, as well as energy informatics.</td>
<td>Real world context, (implementation context): Public building (elementary school) Stakeholders/roles being involved and having influence by in the development process: Pupils, School employees (Teachers, principal, kitchen staff), Parents SME, Research team (Participatory Design, computer science) Openness: Openness was reached by involving several stakeholders into the development of the energy efficiently artifact. This can for example, be envisioned in the involvement of pupils, employees, researchers and SME. Sustainability: Long-term commitment to innovation activities and usage of LL methodologies and tools to which learning experiences are added. Involvement of the SME developing and owning the technology in the process to ensure the sustainability of the artifact.</td>
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</table>
5 Discussion

In this paper we made an argumentation to position the LL as one of the DSR methodologies. In doing so, we looked through how and in what way LL can be a valid DSR methodology. Using Iivari’s (2014) DSR strategic dimensions, we highlighted some common key elements between DSR and LL approach such as IT artifact, innovation, user involvement, and evaluation in the real context. At the same time, bring forward unique aspects of the LL approach, such as openness, evaluation beyond organizational context, emergence of theory, and most importantly sustainability. We also suggested that the strategies are not mutually exclusive, but sometimes they can overlap. These aspects of LL enrich DSR by providing supplementary knowledge in the same manner as ADR informed about the emergent properties that are unanticipated during design (Sein et al., 2011).

Re-interpretation of two exemplar cases illustrated the similarities and differences of LL and DSR methodologies. Both cases following DSR route been through problem formulation, design, implementation and evaluation phase. The projects mentioned in the cases finally generated some design principles. The analysis of the case, however posed some questions to the current DSR methods, for example do we need to have kernel theories from the onset of the project? As the illustrated cases show that in certain design projects, the theory can emerge along the way as the research progresses. The second question arises in this study is do we need to evaluate the artifacts in a closed context, for example experimental lab or particular organizational setup? If we look into LL design projects, evaluation of artifact extended beyond the closed experimental setup or any particular organizational setup toward real environments. The LL approach fully adheres to the argument made by ADR proponents that artifacts emerges during the design process, however, LL also argue that emergence can be happened in open environment. LL approach contributed to DSR community by attracting their attention on the sustainability issues as well. Most of the existing researches on DSR didn’t report how the knowledge in the form of design principles was reused or sustained. These dimensions were discussed conceptually however not applied in practice so far. Therefore, to make the DSR approach more adaptable to the changing design paradigm these dimensions need to be incorporated. For example, as men-
tioned in section 4, LL communities adapt and reapply their cumulative learning experiences in their projects to make it more relevant to the emergent situation.

The paper also contributed to the LL community by rooting the base of LL methodologies in well-established DSR domain. LL methodologies have all the features of traditional DSR approach along with its own unique features. However, little research has been done to position LL as DSR approach. LL has been mainly considered as an environment where different methodologies have been applied to design process (Almirall & Wareham, 2011). However, the piecemeal approach will always create the confusion of philosophical and theoretical underpinning to LL methodologies. Providing a solid DSR base will provide a common platform to synthesize the scattered knowledge in this area.
6 References


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