Association for Information Systems

AIS Electronic Library (AISeL)

13th Scandinavian Conference on Information Systems | Scandinavian Conference on Information Systems

9-8-2022

LEAD USERS AND DESIGN SPRINTS: BUILDING RELATIONS BETWEEN SPACES IN PRODUCT DEVELOPMENT

Magnus R.P Hansen
Roskilde University, magnuha@ruc.dk

Jan Pries-Heje
Roskilde University, janph@ruc.dk

Follow this and additional works at: https://aisel.aisnet.org/scis2022

Recommended Citation

Hansen, Magnus R.P and Pries-Heje, Jan, "LEAD USERS AND DESIGN SPRINTS: BUILDING RELATIONS BETWEEN SPACES IN PRODUCT DEVELOPMENT" (2022). *13th Scandinavian Conference on Information Systems*. 5.
https://aisel.aisnet.org/scis2022/5

This material is brought to you by the Scandinavian Conference on Information Systems at AIS Electronic Library (AISeL). It has been accepted for inclusion in 13th Scandinavian Conference on Information Systems by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

LEAD USERS AND DESIGN SPRINTS: BUILDING RELATIONS BETWEEN SPACES IN PRODUCT DEVELOPMENT

Research paper

Hansen, Magnus R.P., Roskilde University, Department of People and Technology, Roskilde, Denmark, magnuha@ruc.dk

Pries-Heje, Jan, Roskilde University, Department of People and Technology, Roskilde, Denmark, janph@ruc.dk

Abstract

Design knowledge has been conceptualized as a resilient relationship between problem and solution spaces. In innovative product development, though, the problem space is unknown at worst or ambiguous at best and it can be difficult move design knowledge into the solution space. We pursue solutions for this by combining short, intensive design undertakings called "design sprints" with the method of "lead users". We show how formalized design principles from the lead user method and the design sprint method can be extracted, defined, and executed on by applying them to a case setting of climate solutions as innovations. We contribute with both knowledge on the problem as well as on the potential solution through a hexagonal map in a way that aids designers to better understand the resilient relationship between problem and solution spaces. We further contribute to theoretical knowledge by showing how researchers can make transparent the inferences from problem space to solution space.

Keywords: Product Development, Problem Space, Solution Space, Innovation, Climate Technology

1 Introduction

The world needs innovation, and it needs it fast to combat our current climate crisis. Gas and electricity prices are through the roof, and parts of Europe are also experiencing blackouts during peak load times throughout the day. It seems as if the overall problem space of the climate crisis is expanding every two months or so; a much more rapid pace than previously thought. Climate technologies, however, are not cropping up at a similar pace. One reason being that the whole process of identification of problems, conception of solutions, planning, execution, and adoption rate is far slower than the escalation of climate-related issues. Another reason can be that innovative solutions only with difficulty will properly take hold in domains such as households, each with its own routines, habits and social systems as households are located in the private sphere (Zhao et al., 2018). Similarly, the innovations that can be adopted by households are defined as products of product development; an arena where each innovation battles for attention (Choragudi, 2016). Furthermore, a household as a social system seems to be much more complex than just an individual choice to adopt a new digital device, as the dynamics of the household, as well as the technical compatibility, all have to be desirable and feasible (Jensen, Holtz, & Chappin, 2015). One thing is certain: for innovative design of climate technologies to work, they must be relatively complete and useful from their inception. This requires extensive knowledge about the problem space of the households as well as the potential solution spaces.

Recently vom Brocke et al. (Vom Brocke, Winter, Hevner, & Maedche, 2020) in an editorial to a JAIS special issue on Design Science research (DSR) conceptualized design knowledge as the aforementioned relationship between problem and solution spaces as "resilient". This resilient relationship requires the distinction between two types of design knowledge: Omega and Lambda-knowledge. Omega-knowledge "… informs the understanding of a problem, its context, and/or the development of a design entity" (Vom Brocke et al., 2020, p. 525) and Lambda-knowledge about the design consisting of design theories and design entities that contains "…prescriptive knowledge as represented in tangible artifacts and processes that are designed and applied in the solution space." (Vom Brocke et al., 2020, p. 524). One of the challenges for a design science researcher is that the amount of Omega-knowledge about the problem space is limited when you initiate your design undertaking. While a designer often 'builds-and-learns' it is necessary to build Lambda-knowledge to get more Omega-knowledge. However, innovative product development has a limited number of attempts because the household domain can be picky, as well as tire from too many technologies, to choose from.

A very popular method for designing early on after a problematic situation or need is realized is called a *Design Sprint*. This method has been popularized by Knapp et al. (Knapp, Zeratsky, & Kowitz, 2016) who used it at Google Ventures to test out new ideas in order to choose the best and eliminate the rest. In this design method Omega-knowledge primarily comes from in-house users and asking the experts "from around your company" (Knapp et al., 2016, p. 68). While desirable, there is a risk of a tunnel vision of existing knowledge. One way of avoiding this tunnel vision is to involve users that are using the products in new and innovative ways. This idea was promoted by Von Hippel (Von Hippel, 1986, 1989) under the term *lead users*.

Thus, the design-oriented knowledge problem we focus on in this paper is "how to bridge the knowledge transparency gap between problem space and solution space in product development of digital innovations?"

The remainder of the paper is organized as follows. In the next section we take a closer look at our main kernel theories: lead user method, design sprint method and the abstractions necessary between problem and solution space. We then formalize a *nested* design principle that can be relevant for product development of digital innovations. Then, we present a case in which we have applied the design principle. We then discuss the contribution of knowledge practically and academically and how it contributes to the existing kernel theories. Finally, we conclude the paper.

2 Related kernel theories

In this section we take a closer look at lead user and design sprint theory and literature. From each section we infer design principles that later are used on a case.

2.1 Lead users

The main problems with developing new innovative products and services are that the product (solution) is a potential future of use scenarios of unknown territory. In product development, as opposed to in-house developments and consultancy development, getting a hold of users can be extremely difficult as the products developed will be largely voluntary (Grudin, 1991). It can be difficult to find, sample, identify and involve users during product development. Even with users involved, representation in the sampling process is also an important issue (Rasmussen, Christensen, Fjeldsted, & Hertzum, 2011).

In 1986, von Hippel proposed a solution to this conundrum called the "lead user method" (Von Hippel, 1986). The idea was to be able to better assess features that could potentially turn into a new market base by more strongly expanding on the differences between "needs data" and "solutions data" (Von Hippel, 1989). The argument made was that users who are "ordinary" will not be very good at finding solutions to their needs because their familiarity with product features is limited to their own, personal experience. Rather, one should focus on so-called "lead users" who are more innovative because they can see the needs of the future, and because they can see that they will benefit by obtaining a solution to those needs. By identifying and analyzing their behavior and use of technology, novel insights can be found and new products can be designed that otherwise would not have been possible (Urban & Von Hippel, 1988).

While it may seem to be time-consuming, one case study found that the new product could be generated in three days and be half as costly (Herstatt & Von Hippel, 1992) and not nearly as complex as normal product development.

The lead user method has gained popularity in marketing and has taken many additional shapes and forms such as the notion of co-creation, emphasising the importance of involvement and participation of users etc (Olson & Bakke, 2001).

More recent studies have found to apply the concept to service innovation and service quality assessments (Matthing, Kristensson, Gustafsson, & Parasuraman, 2006). While not being cited a lot in DSR literature the concept of lead users has still seen some used by e.g. Peffers, Tuunanen, Rothenberger, and Chatterjee (2007) but also as proposals for how to identify lead users through virtual communities (Bragge, Tuunanen, & Marttiin, 2009; Tuunanen, Bragge, Haivala, Hui, & Virtanen, 2011).

The method involves 4 steps. First step is twofold and involves identifying the dimension of the measures and features in question of the new product. One example given through case studies is the trend of increasing board density of chips (Urban & Von Hippel, 1988), or the trend of establishing pipe-hanger systems that are ease to put together (Herstatt & Von Hippel, 1992). The next part of step one is to assess the potential of users based on the perception of benefits: whether and to what extent a user has performed product modification, whether and to what extent the user has dissatisfaction of the product and the overall adoption time for the user (Urban & Von Hippel, 1988). The second step involves putting together a lead user group to work together, the third step involves generating a product and the final step involves evaluating the product.

Table 1 shows our instantiation of the formalised design principle from lead user literature (based on the structure design principles proposed by Gregor, Chandra Kruse, and Seidel (2020).

For Implementer I	For designers…
to achieve Aim A	…to achieve insight into both the problem space and the solution space of innovative product attributes that provide value…
for User U	for potential adopters…
in Context C	…in product development…
employ Mechanisms M1, M2, M3[…]	…employ exploration, feedback, and assessment techniques…
involving Enactors E1, E2, E3[…]	…involving lead users who develop needs that seem to be general for a future marketplace and who will benefit significantly by obtaining a solution…
because Rationale R	…because normal users are not well positioned to explore the solution space of novel product attributes outside their familiar range of experience.

Table 1. Design principle for the lead user method

2.2 Design Sprints

Designing a solution does not need to take several months. Rather, it can be done in a week. The Design Sprint method is defined by Jake Knapp et al. in his book 'Sprint – how to solve Big problems and test new ideas in just five days' (Knapp et al., 2016). The book defines a Sprint as a unique five-day process for answering crucial questions through prototyping and testing ideas with customers. The first day – Monday – is used for mapping and asking experts about opinions. A team of seven people/designers needs to be recruited (p. 34) for a full week; five consecutive days. Then they gather and map out existing knowledge about the domain area, list several sprint questions (p. 57), and ask "how might we" questions (p. 75) to the challenges identified. Finally, the team identifies a target to aim for (p. 87) in the design sprint by applying dot-voting or another decision techniques. The rationale behind day 1 is that you need a good overview of the domain to get the sprint started well. On Tuesday (day 2) the team starts the day by giving lightning demos (p. 98) and sketch ideas by applying the Mind Reader (p. 105) techniques or the Four-step sketch (p. 109). The rationale for day 2 is that you need to take advantage of the creativity in the team by sketching many diverse ideas. Wednesday (day 3) is for deciding on key functionality. The team decides (p. 131) which solution has the best chance of achieving the target and they take the sketches and weave the into a storyboard (p. 148ff). Thursday (day 4) is for constructing a prototype. The team creates a realistic prototype either on paper, in PowerPoint, as a script your team can perform, in a physical space, or as a physical object (p. 186). And finally on Friday - day 5 - testing and evaluation of the prototype takes place with five real users. One representative from the team interviews five potential real users by conducting a five-act interview (p. 202) while the rest of the team watches and learns (p. 218). Finally, the team decides how to wrap up after the sprint and identify any needed changes for the next iteration (p. 223 and 249).

Table 2 shows the formalised design principle of the full design sprint method.

For Implementer I	For designers…
to achieve Aim A	…to achieve a functional prototype that can accelerate the design and development process…
for User U	…for future developers…
in Context C	…in the initial design phases…
employ Mechanisms M1, M2, M3 […]	…employ knowledge mapping, sketching, a singleton solution focus, low fidelity prototyping and usability evaluation techniques…
involving Enactors E1, E2, E3[…]	…involving a dedicated team of up to seven designers for a full week…
because Rationale R	…because developing prototypes with many people over long time will not necessarily result in quality because most new ideas occur when users engage with the product.

Table 2. Design principle for design sprints

2.3 Requirements and solutions through grounding

Where the lead user method and design sprints provide a method for moving from problem to solution space, the methods do not provide a solution for how to move further into the domain of product development of *innovations,* nor do they provide solutions for how to produce design knowledge that can be utilised between domains.

Explanatory design theory is one example of DSR approaches that emphasizes the importance of elevating specific needs and specific solutions to a more general level. These two concepts are called *requirements* and *components* (Baskerville & Pries-Heje, 2010) and can be understood as having a circular relationship and can take their point of departure in both empirical needs and existing body of knowledge (design theory). General requirements can furthermore be of two different types – inspired by an IEEE standard – namely as a "a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document" (Baskerville and Pries-Heje (2010), p. 274).

Another example that emphasizes the need for theory to play a role before, during and after the construction of artifacts is the notion of theoretical grounding (Goldkuhl, 2004). Theoretical grounding proposes that a large part of the solution of a design is related to kernel theories that helps inform the desired prescribed action to be taken, much like being informed about a solution space that may or may not attain the goal of solving the problem space.

3 Bridging spaces in product development by combining principles

We synthesise the formalised design knowledge from the three previous kernel theories the following way to fit the domain of innovative product development (Table 3):

[redacted]	
For Implementer I	*For designers…*
to achieve Aim A	*…to achieve solutions that can be linked in a transparent way to a problem space…*
for User U	*…for developers, researchers, and practitioners…*
in Context C	*… in innovative product development…*
employ Mechanisms M1, M2, M3 […]	*…Employ 1) the principle of **inquiring** to identify the problem and potential solution space through lead user involvement, 2) the principle of **sprinting** to relate and test specific needs to specific design features, and 3) the principle of **mapping** specific design features to general solutions and to general requirements…*
involving Enactors E1, E2, E3 […]	*…involving designers, developers, and users…*
because Rationale R	*… because innovative product development entails great risks at getting the design right early on and requires a transparent and complicated build-and-learn process.*

Table 3. Our synthesised design principle combining lead user and design sprint literature

4 Case: App for green behaviour

The idea behind the IG Case is to use available regenerative energy in a more efficient way. The demand of electrical power is not constant over the course of a day. The same applies to the fluctuating electricity availability in the power grid during the day. It could be a very sunny day, or the wind could blow strongly, generating more power than can currently be used. Rather than switching the wind turbines off and "losing" the power, would it not be more efficient to switch on additional consumers? However, that requires us to be able to change the behavior in individual households e.g., so they do not start a washer, a dryer, or the charging of an electric car, at peak hours between 6 and 8PM.

We designed a plug that can be mounted between the wall and an appliance. This plug is an IoT device connected to the internet that can be controlled by the electricity supplier. Hence, a consumer can start an appliance i.e., a dishwasher using a mobile phone App. But at the same time establishing an interval in which the appliance needs to wash e.g., between now and 7am tomorrow. The electricity company can then look at forecasting of price and the amount of green energy in the electricity-grid and decide that this specific appliance should run tomorrow morning from 4AM to 5:30AM.

5 Method

Our qualitative method of choice was semi-structured interviews, with a focus on selecting lead users. The interview guide was structured to go through six main areas of content, divided and structured into sections of various research indicators deducted from existing theories on lead users, user adoption, consumer behavior, and behavioral economics and design. Examples included asking open-ended questions about the technological gadgets that made up the overall system that the interviewees used in their everyday lives to support green energy (Von Hippel, 1986), their initial adoption phases and the process of implementation (Rogers, 2010; Venkatesh, Morris, Davis, & Davis, 2003) as well as going through the visuals and functionality of the gadgets (Kahneman, 2011; Sunstein, 2014), and finally discussing how the technology fit (Dishaw & Strong, 1999) with their specific household setting (Rogers, 2010) and their values of being 'green' (Venkatesh et al., 2003).

In total we conducted interviews with 11 lead users in 10 households (Table 4).

[redacted]				
'Martin'	1	01:33:50	Face-to-face	DK
'Donna'	2	00:43:45	Virtual	DK

‘Johannes’	1	00:31:01	Virtual	DK
'Jane' & ‘Arthur’	2	01:01:11	Virtual	DK
‘John’	1	00:53:31	Virtual	DE
‘Jack’	1	00:53:37	Virtual	DE
‘Hannes’	1	00:39:45	Virtual	DE
‘Torben’	1	00:50:28	Virtual	DK
‘Christian’	1	00:52:52	Face-to-face	DE

Table 4. Our interviewees and their data.

Participants were selected through networks, both established in the IG project as well as through professional knowledge networks like the Danish TecPoint consisting of the 25 largest Danish companies. Further participants were selected through snowballing, refined in such a way that the users did not share the similar backgrounds or technologies in their home. Finally, participants who had been in the public media were also invited. Interviews were coded using grounded theory techniques (Strauss & Corbin, 1994). Open coding was mainly performed as debriefings of the interviews and discussions of the general meanings of the choice of words and statements of the interviewees. Axial coding is a way to categorize the codes found in open coding and compare them through various weightings (e.g., finding the attribute of 'height' and extrapolating how interviewees deem that attribute as both 'tall', 'huge', 'short' or 'wide' in the data) was performed based on the collectively constituted meaning from the debriefings. The selective coding was then performed based and inspired from the theoretical foundation from the interview guides and constituted our 'tentative core' based on a general 'pattern recognition'.

The interview analysis followed a three-phased approach. First, lead user interviews were coded using emergent codes close to the textual data and codes representing abstract concepts in the field of study. An example of the latter would be “Solar Panel App.” Second, all the codes were categorized in broad categories distinguishing between problem space Omega-knowledge (Vom Brocke et al., 2020) and solution-oriented Lambda-knowledge (Vom Brocke et al., 2020) observations and distinguishing the relevance between behaviour and sustainability. Finally, the categories were written up as patterns.

6 Results

6.1 Instantiating the principle part of *inquiring*

From the lead user interviews we extracted a total of 17 patterns. Explaining and defining all 17 is beyond the scope of this paper but we have selected 4 patterns where we found many potential solutions and linkages in the following:

Pattern #2. – Peer potential – if someone else can, so can I. Those lead users who had witnessed others in their social circles achieve something, were convinced that such achievement is possible and thus motivated to act in a similar manner. One example lead user had three colleagues at work who became vegetarians on environmental grounds. That convinced the lead user that she could make the same change in her eating habits.

Pattern #3. – Comparing yourself to the average. Seeing the average consumption of gas, electricity or water in the area can be a motivation factor for behaviour change. One user who had designed his own dashboard using an internal web server with Python which was used by the rest of the family too.

Pattern #6. – The price is not a barrier. Participants we spoke to were prepared to pay more to support a change they believe in. In fact, they did not mind paying more if they felt it was better for the environment; a cause most of them seemed to have a strong feeling about prior to throwing themselves in a quest for a sustainable solution.

Pattern #14. – Becoming part of a community. There is a sense of community that is instilled from acquiring new solutions. People feel part of something ‘bigger’ once they have settled for a particular solution. One user who had engaged with other users through an online community and received a lot of technical help. This assured him to stay with the technology.

6.2 Instantiating the principle part of *sprinting*

To utilise the problems and solutions of the lead users we decided to follow an updated 4-day version of a Design Sprint (Smart, 2020) in which Tuesday and Wednesday are grouped together. We also used the lead user patterns described above as our starting point on day 1.

During the course of the first weekday, the key goal for the team was to come up with a system that enables households to monitor their Green Energy consumption, i.e., using Green energy optimally as and when available - and as it is produced. The Sprint questions the team set out to answer were:

- How can we build a system that motivates and enables long lasting green energy usage - even when inconvenient?
- How can we build a system that calculates the likelihood of green energy availability through a plug?
- How can we build a system that connects to ALL appliances in the household?

With these questions as the cornerstone of the design week, the team began following the Jake Knapp's method step by step activities as described in the book (Knapp et al., 2016).

The patterns elicited from the lead user interviews worked out to be a highly useful starting point for designing the app. Patterns #2 and #3 made us discuss how you could compare yourself (as a user) to a peer? We decided to include comparisons to average people having the same household conditions.

The prototype was tested as part of the final sprint day using standardised walkthroughs of scenarios with think-aloud prompts. 4 users that could be considered "ordinary" representatives tested the first prototype. The prototype was iterated on (see Fig. 1) and later tested in two focus groups, both with 6 users.

Fig. 1. *Later version of the app prototype comparing points and performance*

6.3 Instantiating the principle part of *mapping*

The prototype represented a very concrete instantiation of a potential solution space, yet it was not explained, documented nor rationalised. The users who tested the prototype all imagined themselves to be able to use it. This seemed as if the underlying infrastructure was in place with many possibilities to develop further. To make sure that the instantiation of our design also corresponded to *Omega-knowledge*, we first recorded our decisions as user stories (Leffingwell & Behrens, 2009) as rational grounding and justification for the features of the prototype (see **Table 5Table 5**).

[redacted]		
2, 3,5, 9	As an IG User, I want to be able to compare my "Green Points" to selected groups such as "Municipal", "Area code", "Regional" and "National", so that I better can behave green	(Sunstein, 2014) (social norms) (Venkatesh et al., 2003) (social influence)

1,6	As an IG User, I want to be able to sign up for earning ”Green Points”, so that I will be rewarded in a way when I am behaving green	(Krath, Schürmann, & Von Korflesch, 2021) (gamification) (Rogers, 2010) (trialability)
1,6, 12	As an IG User, I want to know how well I am doing in relation to being green. E.g. how many ”Green Points” I have earned, so that I know that my use of IG pays off	(Sunstein, 2014) (disclosure) (Rogers, 2010) (observability)
7,16	As an IG User, I want to be able to get an overview of how I earned ”Green Points” a chosen period, so that I can see that my changed behavior pays off	(Sunstein, 2014) (consequences) (Rogers, 2010) (observability)
2,5, 14	As an IG User, I want to be able to join a community of users, so that I can get IG information including a newsletter	(Rogers, 2010) (knowledge) (Venkatesh et al., 2003) (facilitating conditions) (Sunstein, 2014) (default rules)

Table 5. *Table of sampled user stories and their mapping to kernel theories*

The complete set of user stories was derived from the 17 patterns we identified in the lead user stories combined with brainstorming techniques and kernel theories. The user stories represented the lowest and most concrete level of *Lambda-knowledge* and would be used as a design rationale for the features of the prototype. We ended up with 42 user stories that together constituted a requirements specification for the app.

We abstracted all user stories to general solutions and connected them through a hexagonal puzzle map (see **Fejl! Henvisningskilde ikke fundet.**). Each pattern represented a part of the problem space that could then relate to other patterns or to solutions. The location of the hexes would be placed in such a matter that any hex touching would relate to an adjacent hex. One advantage of doing so is the fact that clusters of hexes would be rather small and could be placed in islands as a stronger overview that could then be related to one another through a connector. For each user story we also added theoretical grounding by identifying related kernel theories.

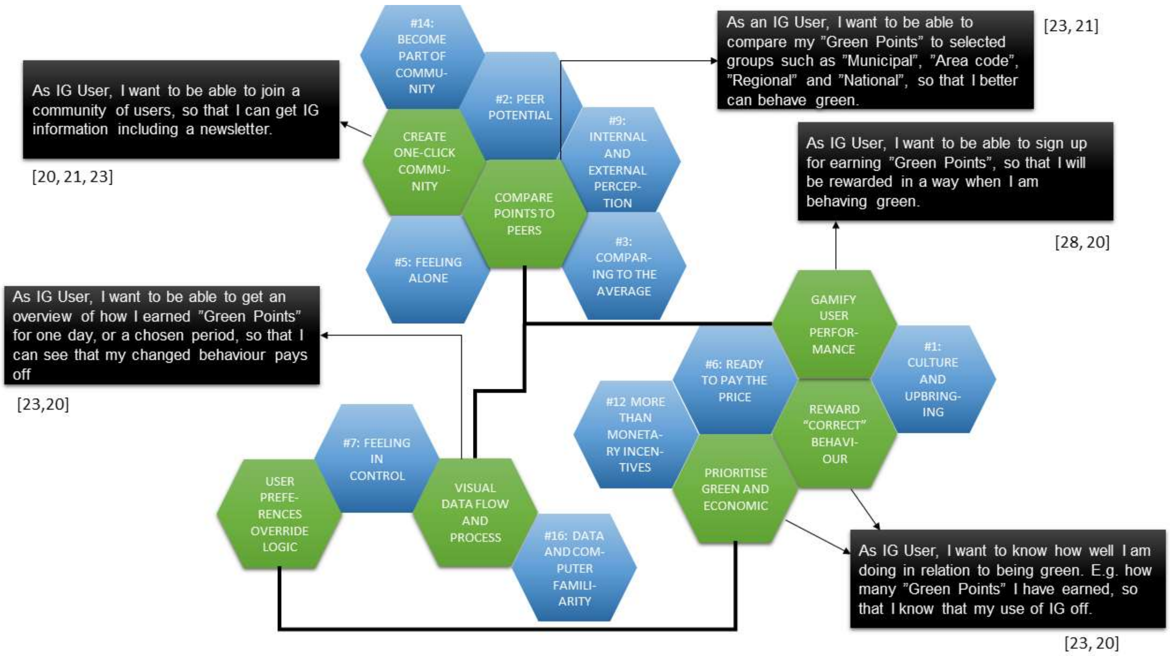

Figure 2. Hexagonal mapping between problem (blue) and solution space (green), including specific solutions as user stories. Black connectors show the relation between the solution hexes

7 Discussion

We have now shown that the dual nature of exploring both problem space and solution space simultaneously to a large extent resides with so-called lead users. As such, we advance Lambda-knowledge (Vom Brocke et al., 2020) within the domain of product development through searching through Omega-knowledge on the super domain of climate technology solutions and their application domains. We formalize Lambda-knowledge from the lead user method, design sprints and explanatory design theory in the shape of a *design entity* of a concrete design principle specifically tailored to the domain of innovative product development. We instantiate the design principle in a case to show how one can group and map concrete problems and solutions which can be considered another Lambda-based knowledge contribution. As such, the design knowledge contribution is that of *contextualization* (Vom Brocke et al., 2020) as our design entity holds more prescriptive power than the kernel theories it originated from, at the cost of generalization potential.

We complement theories such as Diffusion of Innovation theory (Rogers, 2010) and other additions to this, as we provide a principle for the development of the initial innovation that will need to be diffused later. Rogers (2010) and Moore (1998) provide very useful directions in adoption and diffusion strategy, though do not have any concrete prescriptions on how to combine Omega-knowledge on the problem space or Lambda-knowledge on the potential solutions.

Our evaluation of the design principle can be considered an indirect evaluation as the design principle itself as it is not evaluated by other enactors of the design domain (Iivari, Rotvit Perlt Hansen, & Haj-Bolouri, 2021). Nevertheless, we have formalized the principle into a more formal structure (Gregor et al., 2020) and this can make way for more formal reuse potential for a future next step.

Being within the innovative product development domain one could identify the process of evaluation to “quick and simple” according to Venable, Pries-Heje, and Baskerville (2016), though the specific sub-domain, green IT, would call for a far more naturalistic evaluation approach as the ever-escalating issue of power and carbon footprint reduction also calls for continuous behavioural change to be permanent.

We specifically add additional Lambda-knowledge to the lead user method and find that we can involve users even less by combining with a design sprint for this specific type of innovation. While certain case studies have found an economic incentive by doing lead user workshops exploring the design (Herstatt & Von Hippel, 1992), other studies also identified that the involvement of users was still too cumbersome (Olson & Bakke, 2001). Our approach found that users, in certain situations, do not have to be present at all and that the design team, if the empirical and relevant knowledge has been built relatively thoroughly, can be considered competent enough to take advantage of the knowledge of the problem space and solution space combined. In a similar vein, we also add to the design sprint a contribution on which types of users to take inspiration from, as the lead users have posed very useful. As a result, we emphasize the importance of not using ordinary users as the point of departure of the knowledge mapping activity on the first day of the design sprint (Knapp et al., 2016). Instead, lead users have posed to be more reliant as they have more thorough and strong knowledge of problem space and potential solution space. Limitations of our study included the inherent bias of identifying lead users. Identifying, filtering, and selecting is a general criticism raised against lead user involvement (Olson & Bakke, 2001) and our study cannot be free from bias. Nevertheless, we still argue for the validity of the findings because the proposed contribution of this article is using the empirical data as exemplars of how to solve a design-based problem rather than specifically focusing on the empirical findings.

Avenues for further research include using and reusing the design principle as well as the techniques for mapping the Omega and Lambda-knowledge together. Another area for research includes the specific physical constraints of the solution space that our initial mapping did not encompass. Having an IoT device as part of the solution domain does indeed impose certain limitations that other potential solutions, such as tapping to smart metering of the energy consumption, would not.

8 Conclusion

We have used two kernel theories on methods for how to build a relationship between problem and solution spaces, and between Omega-knowledge and Lambda-knowledge, specifically for innovative product development. Through initial interviews with lead users of climate technologies we identified several trends of technology and used the self-developed solutions of the lead users as initial ideas for the solution space. The design objective was solidified by a week of "design sprint" where four of the project partners planned, designed, constructed, and tested a low fidelity prototype. The prototype was tested by 4 ordinary users. Our initial findings confirmed existing knowledge in that the initial involvement of lead users both informed the problem space as well as the solution space and that this, in turn, informed and created both Omega and Lambda-knowledge. Surprisingly, the design case was very straightforward without a need to reiterate considerably. Furthermore, we also contributed with identifying different levels of requirements within the problem space that could be mapped to potential solutions in the solution space based on the knowledge injected by the initial lead user involvement.

Limitations of the study included that certain aspects of the design could not be tested by neither lead users nor by ordinary users, specifically the trend of continuing long-term use of the innovation. We identify this shortcoming as a central part of the method of lead users and design sprints that digital products and services may never overcome. Sadly, this is also one of the biggest contemporary risks in innovative product development, and we call for more research within this area.

Acknowledgments

We would like to thank and acknowledge EU Interreg for the funding for the overall project 'IntelliGrid'. We also want to thank our colleagues Nadine Sandjo Tchatchoua and Frants Christensen for helping with the data collection and design sprint.

References

Baskerville, R., & Pries-Heje, J. (2010). Explanatory design theory. *Business & Information Systems Engineering, 2*(5), 271-282.

Bragge, J., Tuunanen, T., & Marttiin, P. (2009). Inviting lead-users from virtual communities to co-create innovative IS services in a structured groupware environment. *Service Science, 1*(4), 241-255.

Choragudi, S. (2016). India revamps green energy sector: What lies for domestic biogas technology? *International Journal of Global Energy Issues, 39*(6), 413-431. doi:10.1504/IJGEI.2016.079371

Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task–technology fit constructs. *Information & management, 36*(1), 9-21.

Goldkuhl, G. (2004). Design theories in information systems-a need for multi-grounding. *Journal of Information Technology Theory and Application (JITTA), 6*(2), 7.

Gregor, S., Chandra Kruse, L., & Seidel, S. (2020). The anatomy of a design principle. *Journal of the Association for Information Systems*.

Grudin, J. (1991). Systematic sources of suboptimal interface design in large product development organizations. *Human-computer interaction, 6*(2), 147-196.

Herstatt, C., & Von Hippel, E. (1992). From experience: Developing new product concepts via the lead user method: A case study in a "low-tech" field. *Journal of product innovation management, 9*(3), 213-221.

Iivari, J., Rotvit Perlt Hansen, M., & Haj-Bolouri, A. (2021). A proposal for minimum reusability evaluation of design principles. *European Journal of Information Systems, 30*(3), 286-303.

Jensen, T., Holtz, G., & Chappin, É. J. (2015). Agent-based assessment framework for behavior-changing feedback devices: Spreading of devices and heating behavior. *Technological Forecasting and Social Change, 98*, 105-119.

Kahneman, D. (2011). *Thinking, fast and slow*: Macmillan.

Knapp, J., Zeratsky, J., & Kowitz, B. (2016). *Sprint: How to solve big problems and test new ideas in just five days*: Simon and Schuster.

Krath, J., Schürmann, L., & Von Korflesch, H. F. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. *Computers in Human Behavior, 125*, 106963.

Leffingwell, D., & Behrens, P. (2009). A user story primer. *Leffingwell, LLC*.

Matthing, J., Kristensson, P., Gustafsson, A., & Parasuraman, A. (2006). Developing successful technology-based services: the issue of identifying and involving innovative users. *Journal of Services Marketing*.

Moore, G. A. (1998). *Crossing the chasm*. Oxford: Capstone.

Olson, E. L., & Bakke, G. (2001). Implementing the lead user method in a high technology firm: A longitudinal study of intentions versus actions. *Journal of Product Innovation Management: an international publication of the product development & management association, 18*(6), 388-395.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of management information systems, 24*(3), 45-77.

Rasmussen, R., Christensen, A. S., Fjeldsted, T., & Hertzum, M. (2011). Selecting users for participation in IT projects: Trading a representative sample for advocates and champions? *Interacting with Computers, 23*(2), 176-187.

Rogers, E. M. (2010). *Diffusion of innovations*: Simon and Schuster.

Smart, A. J. (2020). Design Sprint full summary - Design Sprint 2.0

Strauss, A., & Corbin, J. (1994). Grounded theory methodology. *Handbook of qualitative research, 17*, 273-285.

Sunstein, C. R. (2014). Nudging: a very short guide. *Journal of Consumer Policy, 37*(4), 583-588.

Tuunanen, T., Bragge, J., Haivala, J., Hui, W., & Virtanen, V. (2011). A method for recruitment of lead users from virtual communities to innovate it enabled services for consumers in global markets. *Pacific Asia Journal of the Association for Information Systems, 3*(2), 31-56.

Urban, G. L., & Von Hippel, E. (1988). Lead user analyses for the development of new industrial products. *Management science, 34*(5), 569-582.

Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: a framework for evaluation in design science research. *European Journal of Information Systems, 25*(1), 77-89.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425-478.

Vom Brocke, J., Winter, R., Hevner, A., & Maedche, A. (2020). Special Issue Editorial–Accumulation and Evolution of Design Knowledge in Design Science Research: A Journey Through Time and Space. *Journal of the Association for Information Systems, 21*(3), 9.

Von Hippel, E. (1986). Lead users: a source of novel product concepts. *Management science, 32*(7), 791-805.

Von Hippel, E. (1989). New product ideas from 'lead users'. *Research-Technology Management, 32*(3), 24-27.

Zhao, D., McCoy, A. P., Agee, P., Mo, Y., Reichard, G., & Paige, F. (2018). Time effects of green buildings on energy use for low-income households: A longitudinal study in the United States. *Sustainable cities and society, 40*, 559-568.