

**HOW PROOF-OF-CONCEPT (POC)
CAN MAKE PEOPLE BE MORE GENERATIVE?
– UNCOVERING THE SISMO’S DESIGN OF ‘GENERATIVE POC’**

Caroline Jobin⁽¹⁾⁽²⁾, Sophie Hooge⁽¹⁾ and Pascal Le Masson⁽¹⁾

⁽¹⁾ MINES ParisTech, PSL Research University, CGS-Centre de Gestion Scientifique, i3
UMR CNRS 9217, 60 boulevard Saint-Michel, 75006 Paris, France
caroline.jobin@mines-paristech.fr
sophie.hooge@mines-paristech.fr
pascal.le_masson@mines-paristech.fr

⁽²⁾ Sismo, 30 rue du Temple, 75004 Paris, France

ABSTRACT

The aim of the paper is to investigate whether Proofs-of-concept (PoCs) are generative in both cognitive and social aspects and what are the methods to reach this potential generativity. This study contributes to the literature of four fields: proof-of-concept, innovation ecosystems, innovation management and NPD, and management in general. In this paper, we adopted a theory-building approach based on a multiple-case study with embedded units of analysis which was allowed by the intervention research at Sismo, a French design studio internationally recognised for its PoC expertise. The main results of this study is that (1) Sismo perform PoCs that are certainly ‘validation’ but which also carries double generativity and (2) the generativity on the organisation is rather stronger than on the object. Their action-learning method is geared to this end, namely to maximise learning especially organisational learning, put the ‘buyers of the PoC’ in action, push them to make discoveries by themselves and even discover themselves.

INTRODUCTION

Proofs-of-concept (PoCs) carry a strange double identity. On the one hand, they will allow a ‘validation’ of a concept, theory or application (Mankins, 1995; Yu et al., 2018). On the other hand, this step occurs at an upstream phase of the development process (Bendavid and Cassivi, 2012; Cooper and Sommer, 2016; Gay and Szostack, 2017) when the collectives that will support the idea are not yet well constituted, allies have to be found, techniques have to be still able to evolve a lot ... Therefore, one does not know if the conviction carried by the PoC comes from the fact that ‘it works’ or from the fact that one has just shown a field of possibilities exists where many things still can be invented on that basis. Moreover, ‘the buyer’ of the PoC was himself able to change his/her preferences during the process (‘learning’ effect and not just ‘buying’ effect). S/he was not necessarily convinced at the beginning and s/he learned things that allowed him to transform her/himself. Therefore, the PoC is a form of ‘validation’ where it could have ‘generative’ effects in the sense that PoC can invent (and not only validate) and cause changes in the actors who goes beyond the maximisation of their buyer utility.

The research questions posed in this paper are the following:

- (1) Is a PoC generative in both cognitive and social aspects?**
- (2) What are the methods to reach this potential generativity?**

To answer these questions, we will rely on the literature in NPD and innovation management which emphasises that actors are not (often) convinced at first and they must change, learn, discover (Christiansen and Gasparin, 2017; Van de Ven et al., 2000).

In this paper, we adopted a theory-building approach (Eisenhardt and Graebner, 2007) based on a multiple-case study with embedded units of analysis (Yin, 2003) which was allowed by

the intervention research (Hatchuel and David, 2008; Radaelli et al., 2012). The intervention research was conducted at Sismo, a French independent design and innovation agency. The research context was particularly rich because Sismo is internationally recognised for its PoC expertise, particularly in the context of Lille Metropole, World Design Capitale 2020. Moreover, they let us think that they pay particular attention to the fact that PoCs carry generativity. Indeed, we also would like to investigate that point: prove that there are PoCs with generativity.

The main result of this study is that Sismo indeed perform PoCs that are certainly ‘validation’ but which also carries double generativity. In addition, this study provides important clarification; this generativity is rather stronger on the organisation than on the object, which Sismo finally evaluates quite ‘as expected’ after the PoC. This method is geared to this end, namely to maximise learning especially organisational, put the ‘buyers of the PoC’ in action, push them to make discoveries by themselves and discover themselves. This study contributes to four fields: literature on PoCs, innovation ecosystems, innovation management and NPD, and management in general. This study can, not only help PoC designers, but also PoC ‘buyers’ and/or ‘users’ by knowing what one can expect. This study also provides a tool for all managers in charge of exploring the unknown and needing a technique to support their action and help them involve new partners.

In a first part, we will provide some theoretical background and present the two research questions with their five related hypotheses. In a second part, the methodology will be made explicit. In a third part, we will present our data and findings which will be followed by a conclusion and discussion part. The end of the paper will be devoted to introduce the contribution to the field and managerial implications.

THEORITICAL BACKGROUND

Genesis of ‘Proof-of-concept’

As far as we have been able to trace back, the roots of “proof-of-concept” have come from the Technology Readiness Levels (TRLs) originally developed by the National Aeronautics and Space Administration (NASA) in the 1960s (Jean, 2016). Such an instrument was developed to measure the maturity level of new technologies and was needed because “the differing perceptions of the researchers and the mission planners between the intended and actual proof of readiness was often the cause of an aborted handoff, or technology transfer, of ART [Advanced Supporting Research Technology] to the SRT [Supporting Research Technology] users” (Sadin et al., 1989). In the mid-1990s, a 9-stage standardised scale was proposed by John C. Mankins (1995) – low maturity is associated to TRL with low index and vice versa – that is now widely spread across the high-tech industry and large programs (Jean, 2016). TRL 3 is described as an “analytical and experimental critical function and/or characteristic proof-of-concept”. “At this step in the maturation process, active research and development (R&D) is initiated. This must include both analytical studies to set the technology into an appropriate context and laboratory-based studies to physically validate that the analytical predictions are correct. These studies and experiments should constitute “proof-of-concept” validation of the applications/concepts formulated at TRL 2” (Mankins, 1995).

Proof-of-concept: an ambiguous definition

The definition of proof-of-concept that is today commonly used by practioners is the one coined by Bruce Carsten in 1984, “a realization of a certain method or idea in order to demonstrate its feasibility, or a demonstration in principle with the aim of verifying that some concept or theory has practical potential. A proof of concept is usually small and may or may not be complete”

(Carsten, 1984). Carsten used this terminology to describe a type of prototype “in which the intent was only to demonstrate the feasibility of a new circuit and/or a fabrication technique, and was not intended to be an early version of a production design” (Carsten, 1984).

Nowadays, proof of concept is widely popular among practitioners (Gay and Szostack, 2017) going from big companies to startups and public institutions and is described in the literature as a “critical step” of the innovation process (Bendavid and Cassivi, 2012). The interpretation of PoC definition varies by person, project, company, and industry (Cartwright et al., 2010) especially as it widens over time. Indeed, Cooper and Sommer (2016) in its agile stage-gate hybrid model describes “protocepts [see proof-of-concept prototypes] are used not only to seek customer feedback and validation often, early, and cheaply, but they also reduce technical uncertainties, since they can be used to demonstrate preliminary technical “proof of concept” early in the Development phase.”

This literature review seems to reveal that the definition of the PoC is based on an ambiguity and that this ambiguity could even explain the success of the notion. Indeed, the definition says that it is about ‘validation’ but also says that it can be incomplete – therefore partial validation – and it is perhaps this partial side that is interesting because there would be still unknown and perhaps it is precisely this unknown that interests the actor ‘entering’.

Furthermore, PoC definition seems to carry another ambiguity on the notion of demonstration. Is it a ‘proof’ related to previously known criteria or is it a show that ‘makes one want’? Indeed, is it only about ‘validation’ or is the value of the POC somewhere else – a way to convince, to seduce, promise, make discover to the ‘receiver’ new dimensions, or create an engagement towards directions he did not know yet?

NPD and innovation management literature

Moreover, the literature in New Product Development (Cooper and Sommer, 2016) and innovation management (Gay and Szostack, 2017) suggests that these assumptions may not be impossible. It can be first evidenced by the innovation journey developed in the context of the Minnesota innovation research program directed by Van de Ven that aimed to answer the encompassing question: ‘How and why do innovations develop over time from concept to implementation?’ (Van de Ven et al., 2000). In the upstream phases, the design collective is still divided, and new partners have to be found, hence the necessity stressed by many authors to enlist, convince, envy, etc. actors (Dubois et al., 2014). For instance, Borup et al. (2006) described expectations as essential in the intermediation of different actors and groups. Moreover, Van Lante et al. (2013) consider expectations as performative in the sense that they attract allies and resources, coordinate activities by defining roles and building mutual obligations, and go beyond words by materialising through experiments and prototypes. On this point, design objects are generally presented with a hybrid nature: representation and translation (Mer et al., 1995). This idea is based on the actor-network theory (Callon, 1986), according to which the objects are active, just like the actors of a project and that translation operations make it possible to “establish an intelligible link between heterogeneous activities”. According to Akrich (1987), the object beginning to incarnate induces various types of action, including inclusion or exclusion of certain actors by the constitution of a socio-technical network and the emergence of relations between actors. Gay and Szostak (2017) see in the recombination of tangible and intangible assets that mentioned Teece (2007) the demonstration of organisational creativity and dynamic capacities (O’Connor, 2008). Moreover, at the upstream stages, the team, the sponsors, the clients, ... are not yet maximising their utility but have to discover value axes – these are phases of high generativity, both on object and organisation perspectives (Hatchuel and Le Masson, 2009; Hooge, 2017; Subrahmanian et al., 2017).

Therefore, a PoC in the upstream phase would not be only for validation but also for generativity, and generativity would both focus on the object and the organisation.

Research questions and hypotheses

After making sure that, we will investigate two research questions:

(RQ1) Is a PoC generative in both cognitive and social aspects?

(RQ2) What are the methods to reach this potential generativity?

The literature review and the claim of Sismo allow us to make some hypotheses:

(H1) The PoCs described by Sismo are really PoCs, namely, their vocation is to convince an actor to continue in the explored way and to 'validate' certain dimensions for the future exploration.

(H2) There exists 'generative' PoCs that have a regenerative effect, going beyond the traditional definition of pure validation. Thus, it is not (only) a question of validating things but also of showing that one can move the lines in a dynamic of transformation (their graphic representation is not a point but an arrow)

(H3) The regenerative effect occurs both on cognitive and social perspectives (there are no horizontal or vertical arrows)

(H4) The regeneration effect of this 'generative' PoCs is done synergistically between the object and the organisation (the arrow has a specific orientation – diagonal – and sense – positive)

(H5) These presupposed regeneration effects do not have an endogenous origin (or at least not only) but depend on the ability of designers to overcome cognitive and collective biases.

METHODOLOGY

Research design

In this paper, we adopted a theory-building approach (Eisenhardt & Graebner, 2007) based on a multiple-case study with embedded units of analysis (Yin, 2003) which was allowed by the intervention research (Hatchuel and David, 2008; Radaelli et al., 2014) conducted at Sismo, a French independent design studio, since October 2018. To respond to the first research question, a quantitative study of 12 PoCs designed and performed by Sismo was conducted with a questionnaire. 4 out of these 12 PoCs were further investigated in a qualitative study based on interviews and archival data investigation to respond to the second research question.

First case selection and evaluation (quantitative study)

Over the period from 2016 to 2019, 18 PoCs were identified at Sismo. 6 were excluded from the study for two main reasons. 2 PoCs that had been designed by Sismo were conducted internally in autonomy by the client organisation thus making the complete formalisation and evaluation impossible by Sismo's project stakeholders. 4 PoCs were side-lined because a trio of project stakeholders was not available to perform their evaluation due to staff turnover. The presentation of the 12 remaining PoCs is provided in the appendix.

For reasons of triangulation of the data, each PoC was evaluated at least by three Sismo's project stakeholders with different status (co-founder of Sismo, middle manager, project manager and technical expert (who can have a background of designer, architect or engineer)). 19 people were mobilised to assess these PoCs. This group represents a large part of Sismo's workforce (about 35 people). In case 1, the "project manager" who evaluated the PoC was not present at the time of the PoC but he then took over the torch to ensure its deployment. For cases 6 and 12, there were 4 assessments with a status redundancy for case 6. For cases 11 and 12, the lead author of this paper contributed to their evaluation in the context of intervention

research. Each evaluation lasted about 20 minutes and a majority of them was performed in the presence of the same author. Care had been taken to ensure that the first assessment was done in that presence to ensure the proper understanding of the questions.

Questionnaire design

Methods were needed to evaluate the generativity of PoCs: are there new functions?, etc. As the study of formal models of design theory has shown that they can all be characterised by their capacity to account for a form of generativity (Hatchuel et al., 2017), axiomatic design (Suh, 1999) and C–K design theory (Hatchuel and Weil, 2009) were chosen as evaluative frameworks. These methods can also be used to evaluate the learning (Hatchuel & Le Masson, 2007).

The evaluation was performed with a questionnaire based on both (1) cognitive and (2) social perspectives. The form was composed of eight double questions – four were related to the effects generated by the POC on the object (1) and the four others were related to the effects generated by the POC on the organisation (2).

- (1) Cognitive generativity assessment: For each question, a double evaluation was requested: (A) In my opinion, one of the goals of the POC was to ... and (B) In my opinion, the POC made it possible to ... The assessment was performed with a Likert-type scale of six items and thus a "forced choice" method since the neutral option was removed. A "strongly disagree" response was associated to 0 point whereas a "strongly agree" response was associated to 5 points. The larger the index of the question is, the greater the degree of generativity associated is. Indeed, a weighting index was associated for each question to calculate on the basis of 20 points the generativity on the object which is the weighted sum of the answers to these four questions.

Table 1: Framework of cognitive generativity assessment

Question number	Formulation of the question	Axiomatic design	C-K operator	Degree of generativity	Weighting
1	... validate / invalidate hypotheses formulated before the experimentation.	Valide/Invalide the relationships between FRs and DPs ($\Theta_{FR} = 0$; $\Theta_{DP} = 0$)	$K \rightarrow K$	Low	1
2	... refine (in terms of exactness or degree of detail) the concepts and / or the understanding of the needs / problems of the users.	Edit DPs or FRs without changing relationships ($\Theta_{FR} = \delta_{FR}$; $\Theta_{DP} = \delta_{DP}$)	$K \rightarrow C$	Intermediate	2
3	... bring out new concepts to meet needs that have already been identified.	Create new DPs without changing FRs ($\Theta_{FR} = 0$; $\Theta_{DP} = \Delta_{DP}$)	$C \rightarrow C$: restrictive partition	Advanced	3
4	... bring out unknown needs / problems before the experimentation (and possibly new associated concepts).	Add new FRs and thus DPs ($\Theta_{FR} = \Delta_{FR}$; $\Theta_{DP} = \Delta_{DP}$)	$C \rightarrow C \rightarrow K$: expansive partition, C0 reformulation	High	4

- (2) Social generativity assessment: For each question, a double evaluation was requested: - for question 5-7: (A) before the PoC, (B) after the PoC – for question 8: (A) during the early phases of the project, (B) during the PoC. Indeed, the goal of this evaluation is to assess the social aspect in the context of a project under design.

Table 2: Framework of social generativity assessment

Question number	Formulation of the question	Related ability	Scale
5	Can you associate a percentage for each of the following types of behaviour to the project stakeholders (except Sismo's)? <ul style="list-style-type: none"> - Promoters (favourable to change, they position themselves as prescribers) - Passive (Waiting for convincing results, they want to be secured) - Opponent (Opposed to the projects, they systematically advance arguments against) 	Foster/Hinder change management	See above
6	On average, what level of relationships existed between the initial project stakeholders (except Sismo's)?	Improve / degrade relationships between people	Collaboration Scale (Hogue, 1993)
7	In your opinion, what was the level of mastery of the Design Thinking methodology by the initial stakeholders of the project (except Sismo's)?	Acquire / lose skills and methods of design	None, Initial, Basic, Operational, Advanced, Expert
8	How many functions and/or partners were involved in the stakeholder circle (except Sismo's)?	Integrate / exclude actors, extend / reduce the designer collective	See above

For questions 6 and 7, there is a direct relation between the answer and the score. For question 6, respondents were asked to what extent the client collective(s) collaborated with each other on a scale ranging from 0 to 5, with 0 indicating no interaction at all and 5 indicating the collaboration level, using Hogue's (1993) taxonomy. For question 7, a classical scale was used to assess a degree of mastery (none, initial, basic, operational, advanced and expert). A none level was awarded with 0 point whereas an expert level was awarded with 5 points.

For questions 5 and 8, there is a reprocessing of the data to arrive at a score between 0 and 5. In the context of question 5, the respondents sometimes cut the column into 2 or even 4 different groups. In this case, the average of these columns was made for each of the types of behaviour. These percentages were then be converted into a rating from 0 to 5. - If the percentage of opponents was the strongest, then the number of points awarded was 0 or 1. It was 0 if the percentage of passives was higher than the percentage of proactive, otherwise it was 1. - If the percentage of passives was the strongest, then the number of points awarded was 2 or 3. It was be 2 if the percentage of opponents was higher than the percentage of proactive, otherwise it was 3. - If the percentage of opponents was the strongest, then the number of points awarded was 4 or 5. It was 4 if the percentage of opponents was higher than the percentage of passives, otherwise it was 5. In case of equal percentages between behaviours, priority was given to highlight the dynamics between before and after the POC. The consistency of these notes was verified by comparing similar cases for other POCs. In question 8, the maximum answer was identified and associated to a 5-point ranking. Then, classes were created: 0 point for 0 actor, 1 point for 1 or 2 actors, 2 points for 3 or 4 actors, 3 points for 5 or 6 actors, 4 points for 7 or 8 actors and 5 points for more than 9 actors.

Second case selection and evaluation (qualitative study)

In parallel with this quantitative evaluation, a qualitative assessment was carried out on 4 of these 12 PoCs. This is neither a random selection nor a selection purely based on the amount of information available. They were selected in the idea that it would be extreme cases and that

they would have dissociated trajectories. Each narrative will be based on the same framework: initial context, presentation of the project, characteristics of the PoC, design of the PoC, setup and animation of the PoC, review and rest of the PoC, and findings.

DATA/FINDINGS

Quantitative study (12 PoCs)

Data

The detailed results of the quantitative study are presented in the appendix. A graphical representation of the evaluation of the 12 PoCs is presented in Figure 1. How was the graph obtained? For each question, the average was made between the answers of the 3 or 4 respondents. (1) For questions about object and cognitive effects, a weighted sum of answers to questions 1-4 was made – this value is found on the y-axis. (2) For questions on organisation and social effects, a simple sum of the answers to questions 5-8 was made – this value is found on the x-axis. The rounds represent the results obtained in questions A which were related on

(1) a projection of the effects of PoC on the object and (2) an estimate of the state of the organisation before the start of the PoC. The triangles represent the results obtained in questions B which were related to (1) an estimate of the actual effects of PoC on the object and (2) an estimate of the state of the organisation after the end of the PoC. The arrows represent the effects generated by the PoC process in both cognitive (on the ordinate) and social (on the abscissa) terms. The hard arrows represent the 4 cases that will be studied in the rest of the paper and the dotted arrows the 8 other cases.

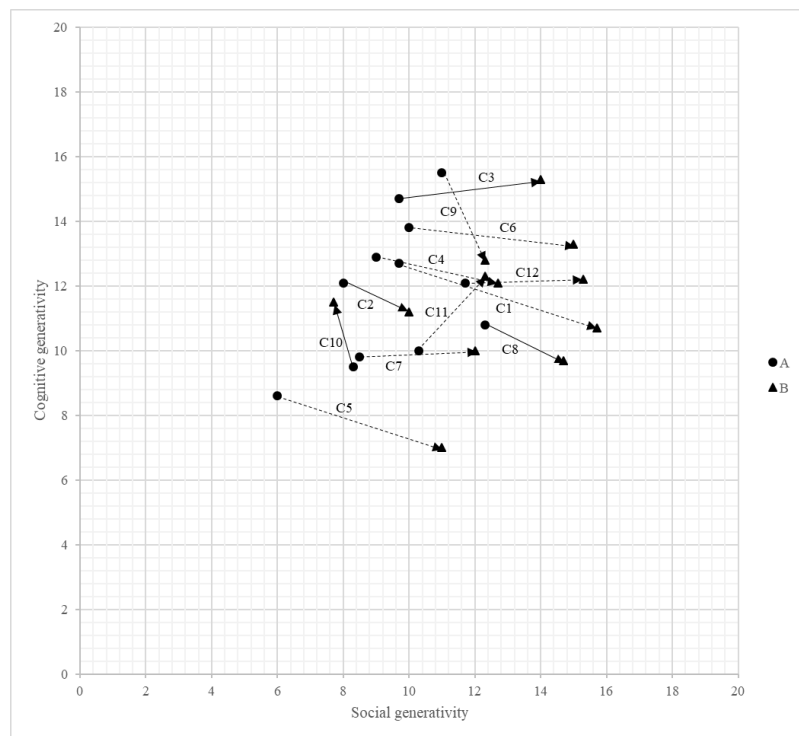


Figure 1: Graphic representation of cognitive and social generativity assessment of 12 PoCs

Findings

According to what the theory predicts, the points should be in the lower left frame of the chart and we should not observe arrows. Thus, through this study and graph, we reveal that the PoC contains an unexpectedly variable power. The location of the points A regarding the y-axis shows that Sismo has many other ambitions than the simple validation of hypotheses, which is however variable. While one tendency was expected (\nearrow), 3 out of 9 possible trends ($\cdot, \uparrow, \downarrow, \rightarrow, \leftarrow, \nearrow, \nwarrow, \searrow$) were observed including the expected synergistic (\nearrow) for 4 PoCs: a positive social generativity associated with a positive cognitive generativity and 2 antagonists (\searrow, \nwarrow): positive social generativity associated with a negative cognitive generativity for 7 PoCs

and negative social generativity associated with positive cognitive generativity for 1 PoCs. In 9 out of 12 cases, the effects on the organisation were stronger than the effects on the object.

If we go back to the first research question (RQ1): Is a PoC generative in both cognitive and social aspects? and the hypothesis made (H1,2,3,4), here what can be said.

(H1) The PoCs described by Sismo are really PoCs, namely, their vocation is to convince an actor to continue in the explored way and to 'validate' certain dimensions for the future exploration.

According to the high rating provided (on average 4.4/5) at the question 1A: One of the goal of the PoC was to validate/ hypotheses formulated before the experimentation?, we can state that Sismo's PoCs meet the definition of PoCs in the literature. We validate this hypothesis.

(H2) There exists 'generative' PoCs that have a regenerative effect, going beyond the traditional definition of pure validation. Thus, it is not (only) a question of validating things but also of showing that one can move the lines in a dynamic of transformation (their graphic representation is not a point but an arrow)

The non-superposition of points A and B which manifests itself as a non-zero vector in the graphic representation shows that PoC can have, in a systematic way, a transformative and generative power. We validate this hypothesis.

(H3) The regenerative effect occurs both on cognitive and social perspectives (there are no horizontal or vertical arrows)

The generated learning is well expressed at the same time according to cognitive and social perspectives although it is overall more subtle for the object. This means that the designers had, a priori, granted the PoC to a strong generativity on the object (average: 11,9/20) and the realisation of the PoC does not produce major unexpected discoveries. They had 'planned' the discovery. We validate this hypothesis and add the point that the regenerative effect of the object is rather well planned.

(H4) The regenerative effect of this 'generative' PoCs is done synergistically between the object and the organisation (this arrow does not have any orientation – a diagonal and sense – positive)

For a third of the PoCs, there was a double positive generativity on the object and the organisation. In this sense, we validate this hypothesis, however, it is not sufficient to describe all the dynamics. Indeed, the majority of the effects produced, contrary to what had been envisaged, are antagonistic between the object and the organisation with predominantly a positive social generativity associated with a negative cognitive generativity, meaning that PoCs generally did not allow Sismo to be as audacious in terms of generativity on the object as expected.

We will now study in detail the 4 cases (C2, C3, C8, C10) which should allow to advance answer elements on the second research question related to the question of the method and our last hypotheses (H5). We can mention that graph shows that the choices of the 4 PoCs were quite well done because they are rather extreme and describe all 3 observed trends.

Qualitative evaluation (4 PoCs)

Case study n°2

Initial context

Organisation: The client was a cooperative supermarket chain without sales relationship between headquarters and supermarket directors – every retail store is a standalone company. Indeed, a great freedom is given to each supermarket director in terms of human resources, products offered, new initiatives, ... who in return must give time to headquarters. Indeed, when a field experiment works well at one store, it generally quickly goes back to headquarters that grabs it and facilitates its optional deployment around all supermarkets.

Object: Field staff made the observation that there are many items in stores which are very heavy, and some people have difficulties to carry these heavy loads (elderly, frail people, ...).

Presentation of the project

The proposed idea was to offer support to clients for all heavy items. These problematic and idea were grabbed among others by innovation department of headquarters. Sismo were asked by headquarters to develop and test the concept. The concept consisted in a three-step service: (1) scan with the supermarket mobile application the label of your heavy item that is identified with a tag to inform the availability of the service for this product, (2) present at the scan desk a bare code on your smartphone that the cashier will scan, (3) collect your heavy items at the store's drive.

Characteristics of the PoC

A PoC was settled to check the desirability of such a service. The PoC lasted four and half days from Monday to Friday. It took place in a supermarket in Paris suburbs in September 2016. The PoC was supported by the director of this store and involved only people from this store (operational manager, drive chief, and agent cashiers), the innovation department of headquarters positioned itself very far behind.

Design of the PoC

The first step of the PoC design was to choose the experiment field and the products for which support can be asked. These choices emerged from exchanges between Sismo and headquarters teams. The director who accepted to welcome the PoC in his store was asked to send to Sismo the labels and miniatures of the chosen items. Very few elements were required for the PoC in the sense that the idea was not to develop the application. Indeed, labels were prepared and printed and position at the item level thanks to basic plastic supports. T-shirts were flocked at the image of the service concept and wings were manufactured for the item carriers. Finally, meetings with the director and manager of the store who deeply believe in the concept and the drive chief were organised before the launch of the PoC.

Setup and animation of the PoC

Monday morning was devoted at the installation of the PoC. Sismo team was put in contact by the store manager and drive chief to the supermarket staff. Drive teams were asked to provide materials (wheeled bins, walkie-talkie, ...) and access to the drive. Cashier were asked to inform Sismo team by walkie-talkie when someone arrived at the cash desk with service labels. For five days, three Sismo employees (a trainee designer that was the project manager, a designer apprentice, a non-designer especially recruited for this PoC) were directly involved to promote and perform the service concept (item carrying to the drive). Sismo's middle manager came at the store in the middle of the week. Observations and interviews were continuously performed during opening hours in order to understand why it did not succeed as hoped and

thus make adjustments. Iterations were mainly performed on the list of items subject to the service and service promotion.

Review and rest of the PoC

A major misuse of the service was observed, it was rather the healthy and young people who used the service contrary to the initial targeted population (frail and elderly people). This behaviour can be explained by two reasons – the first is related to a self-esteem brake, especially from elderly husbands who shop with their wife and the second is related to the non-awareness of loss of physical resources. This PoC was a failure in the sense that the service was not working but a success in the sense that it avoided pointless significant investment including the development of the mobile application. A priori, everyone in the client organisation and Sismo was convinced that it would work: "We wanted to convince ourselves of this idea, we were like lawyers, we wanted with this PoC to show that it was a good idea" (Sismo's project manager). Contrary to cash and drive agents that had a passive behaviour, surprising behaviour were observed from the Sismo non-designer and "outside" people. Indeed, the project manager was surprised by the important implication of the non-designer that were especially recruited to help carrying items: "He was so motivated, it broke his heart that it does not work, [...] he was looking for solutions" (Sismo's project manager). Moreover, four young women who were distributing prospects in the store for an association were bored and came to help Sismo. No client restitution took place and the project was simply abandoned.

Findings

This case was interesting to investigate because it is a case of negative validation in which the discovery did not go further; it was for this reason that he was chosen. The case description clearly showed that this is a case of surprise on the object (which induced a negative cognitive generativity) and positive generativity on the organisation, which can be explained in particular by a competence-building in terms of methodology.

What does this case allow us to learn about the method? Under this project, all the usual phases of the Sismo innovation process have not been performed by them, particularly the ethnographic phase. They have thus developed a descriptive model of the functioning of the studied system, here the supermarket and its customers on the basis of their own experience. This may have limited their ability to rebound, especially since Sismo's stakeholders were designers in training and non-designer. Organisational learning was probably restrained by the fact that the innovation team of headquarters was not present at the PoC and the supermarket teams were very little perceived as potential designers and rather as mere implementers, and no PoC restitution was performed to the client.

Case study n°3

Initial context

Organisation: The client organisation was a governmental employment agency that employs 54,000 employees in more than 1,000 local branches and relays. On the one hand, we had an innovation team in headquarters, very dynamic, acculturated to innovation, agility and testing, who had successfully brought a digital innovation project. On the other hand, it had been three years since a lot of projects were pushed by the general direction to local agencies generating a feeling of saturation to novelty. In these agencies, there is a small part of people who are very

proactive. They already have the soul of some designers while others also have initiatives but have trouble putting them forward.

Object: The agencies experience strong periods of affluence each month at the time of the update period. This update of each jobseeker situation conditions the reception of the governmental aids. This tended to generate tensions, where unfortunately it was not uncommon for security officers to intervene, when there was one. More generally, over the entire period of the month, there was a climate of tension that led to the implementation of drastic security measures and mistrust of one another.

Presentation of the project

Sismo started working with the agency through a preliminary study that allowed them to propose a new division of agencies with related functions and services. They started the project in November 2016 with a series of field observations (one day at four agencies with different typologies and problematics that were geographically distributed on the metropolitan territory and different from the preliminary study) and interviews (19 counsellors and 27 jobseekers). They then performed four collaborative workshops (each based on one of the following thematic: comfort, simplify, collaborate, excite) where counsellors from nine agencies distributed on the metropolitan territory and few jobseekers took part. Ideas that emerged from those workshops were reworked and took shape in scriptwriting.

Characteristics of the PoC

In February/March 2017, the PoC took place consecutively in two of the four agencies (agency α and γ) where observations had been performed and another in a central district of Paris (agency β). For feasibility reasons, one subspace could not be tested in the context of the PoC. As it was too heavy to test the five remaining subspaces and related services in one agency, subspaces were tested where it made the most sense with only one redundancy between the three agencies (two reception areas and interview space in agency α , collaborative space in agency β , and interview space and back-office in agency γ). The first agency hosted the PoC for two weeks but asked to continue another two weeks to fit observations with the one-month cycle of the agency. The two other agencies hosted the PoC for one week. The PoC was also performed in six other agencies identified by regional and territorial directorates but was only supported by internal project team and not by Sismo.

Design of the PoC

The design of the PoC was very intensive because of a very short schedule imposed by the client in connection to the political agenda. Meetings between Sismo and the agency regularly took place to design the three PoCs and some missions had been divided, for instance, IT to the agency. From the client side, different contact points were clearly identified: one for each agency and one for each function: IT, property, ... For each agency, Sismo had to retrieve plan agencies to better arrange subspaces, organisation of flows between subspaces and other spaces, signage, personnel, tools and services. Several back and forth were needed for client validation with security issues that reach its height. Knowing that the first PoC was to take place in mid-February, some things and purchases had to be anticipated, which meant that they had to do in parallel the design of the concepts through scriptwriting and translation for the design of PoC. This had the effect of reducing the initial ambition of the project because the client was immediately projecting in the practical realisation of the concepts. The PoC was presented to the director of the first agency two weeks before its launch. She hardly believed

that in two weeks, all would be in place. A kit was prepared for the six other agencies that had to perform the PoC in autonomy but with the help of the client project team. In this kit was presented methods and purpose, test protocol, observation method, POC synthesis & observations with examples.

Setup and animation of the PoC

Two or three days before the launch of each PoC, the Sismo team started the set up of the PoC in an isolated room (furniture assembly, elements painting, ...). It was also the first contact point with counsellors who were curious and started to give their opinion on the chosen colours or the types of plants. From that moment, the Sismo team had to be very informative to explain what would happen and respond to their question and fear. The day before the launch of each PoC, the Sismo team performed the installations without disturbing the life of the agency and presented the project to the counsellors and especially their new posture of service (role and mission, welcome posture and vocabulary) in the presence of the agency project team. As some IT issues occurred at the launch of the first PoC, IT teams were asked to perform upstream tests for both other agencies.

During the first two days of opening, the Sismo team composed of three designers helped counsellors find their marks and answered their questions. Throughout the duration of the PoC, the Sismo team added things and continuously adapted concepts based on observations and interviews of the counsellors. In agencies α and β , the interviews were performed between the counsellor and Sismo's designers whereas in agency γ , restitutions took place in the presence of other counsellors in an area that was tested during the PoC and aimed at creating new relationships. The size of the first agency (α) with its 100 counsellors had been a real challenge for both witnessing and the gathering of data. It was recommended to propose solutions to the problems observed. Several devices have been tested without much success, however on the side of the client project team, an effort was made to trace daily the information through a shared document.

Review and rest of the PoC

Although the experience between the three agencies was very different, a common point was highlighted. It was very violent and illusory to want to repack all the things that were tested and return to the starting state after the days of PoC pending the wave of official deployment. Thus, the counsellors asked to keep certain things knowing that the Sismo thought to be able to recover them for the following PoCs. More than devices, the PoC has introduced new postures, mentalities, relations that were hard to set up but also to give up at the end of PoC, hence that caused frustration. Sismo had been in a complicated posture in agency α because the counsellors that well received change did not dare to share their point of view in front of the opponents who then monopolised the time. The presence of trade union during the PoC was not also easy to manage. Overall, the three agencies had been very much accompanied, even too, contrary to the six others where counsellors had to understand and appropriate the approach.

The restitution of the three PoCs was enriched by the six other PoCs conducted. These returns did not introduce many new significant elements but above all allowed to explain which were the most relevant devices according to the agency configurations. For example, in the context of low-flow agencies, the presence of a senior orientator-counsellor to welcome and direct job seekers to the right place is not necessary or not all the time. Also following this complement,

a deployment kit-based notebook was produced presenting both the methodology and the protocol to follow to implement the imperative and optional elements to be certified as well as their different levels of implementation depending on the available resources (financial means, human resources, size of the agency). The deployment began in waves in voluntary agencies with the help of the general direction and sharing of documents and good practises. Help was asked to Sismo for the agency α because difficulties occurred during the deployment. The case of this agency is a bit special because it also experienced a profound architectural change that did not integrate or distort the recommendations made by the Sismo. More generally, this case agency showed in comparison with other agencies where the deployment went very well (for instance, agency γ) that the good initial atmosphere, and interest and appropriation of the design thinking method by both local management and a critical mass of counsellors is essential for putting in place the appropriate devices, making these live and evolve. Indeed, more than the deployment of new agency models, this project has infused a new state of mind that was not necessarily perceived by the Sismo's project manager in the initial brief.

Findings

This case was interesting to investigate because it embodies the success story that is often put forward by Sismo and according to the statements of one of the two co-founders, it is the PoC that allowed the most learning from a point of view of Sismo. Moreover, this PoC described a case of positive synergic generativity in cognitive and social terms.

What does this case allow us to learn about the method? This double transformation seems to be related to the highly co-design process and the nature of the support. Indeed, the learning seems to have been all the more significant and beneficial in the long-term that what was instilled was not the asperities of the service imagined but the method that allowed Sismo to design and sustain these. This seems all the more true and necessary in the case of services because there cannot be a smooth reception and, on the contrary, the agent must generate knowledge in order to be able to appropriate the prescriptions made.

Study case n°8

Initial context

Organisation: The client was a flooring manufacturer. The company employed designers, had a strong theoretical knowledge of design thinking with its own internal methodology, and was also used to work with design studios. They have a studio they present not as a place of exhibition but of experience of the brand. It is not only a showroom but also a space for exchange and co-creation that also hosts development projects.

Object: The company was specialised in flooring and wall with materials presented as decorative (aesthetics, colours) and functional (practical washing, ...).

Presentation of the project

The project aimed at reinventing the transition in a broad way. As the client organisation had its own internal design thinking methodology and agenda, a mixture of client organisation and Sismo methodology was performed in order to develop the design process methodology. The project started with an ethnographic phase to understand the issues related to transition. Duos of a designer from Sismo and an individual from the client organisation went to France, New York and Copenhagen. Then, a co-creation workshop that took place during an annual fair focused on floor covering brought together designers from Sismo and employees from the

client organisation who worked in creation and R&D. Through the design process, the project was gradually focused on the transition in the flooring universe then from a floor to another. The very product-oriented ideas that emerged from this workshop in addition to the following meetings with the client gave birth to three concepts.

Characteristics of the PoC

The three concepts were tested in two different contexts. A concept (1) was tested during half a day in the client organisation showroom where architects were invited to introduce the transition solutions sample and understand their vision and their doubts. The two other concepts (2)(3) were tested through an in-situ installation in a hotel and conference centre half a day for a concept (2) and only two hours for the other (3). The people involved during the PoC were mainly designers from the client organisation and internal structures that help producing the samples.

Design of the PoC

A preliminary meeting was organised with the client organisation to share the design activities of the PoC. Indeed, the client organisation provided a lot of energy, especially for the sample prototyping. The field of experimentation was easy to find for the first concept because the client studio was already there contrary to the field of experimentation for the two other concepts. Firstly, Sismo suggested to perform the test in the entrance of the client organisation headquarters building but they refused the proposition and offered another space in the building, but it was not appropriate for the PoC. At that time, the network of the project manager from Sismo, who was an architect, was very important. Thanks to him, an establishment gave its trust and accepted to open its door for the experimentation without financial rewards. It was also in the Sismo project manager network that invitations were sent for the first concept testing. For the second concept, they designed and manufactured modular samples that perfectly fit with the building architecture to be able to quickly change things following user reactions.

Setup and animation of the PoC

The setup of the first PoC was easy because the showroom was dedicated to host samples. The setup had to be quick for the second concept not to disturb the life of the establishment. The entrance carpet was replaced by a solution prototype. For the third concept, a projector was put in place. For both in-situ experiments, a camera was installed for remote viewing.

For the concept tested with architects, feedback from them were collected and when adaptations were possible, they were performed. For the experimentation in the hotel and conference centre, designers observed user behaviours through the camera to prevent the introduction of a bias. When a strange behaviour was observed, users were interviewed by Sismo designers and a Sismo business developer. Otherwise, the project manager was particularly surprised by the interest and involvement of the architects who were invited to the first PoC. Indeed, it would seem that open innovation is not common with this kind of organisation and architects are therefore not usually requested to take part in the process of new products development. In this sense, this PoC is particularly interesting because what was to be primarily oriented as a commercial evaluation has turned into a moment of co-creation thanks to the enthusiasm and strength of proposals of architects.

Review and rest of the PoC

According to the project manager of Sismo, the results were not really convincing because of the reduced time and means. Among the three PoCs, the third that was the most ambitious and away from the core business was not really selected. The restitution of the PoC with the client was particularly difficult because the director of the client organisation, who had been very sceptic from the beginning of the project, gave strong opinions on both Sismo's methods and conclusions.

Findings

This case was interesting to investigate because Sismo worked with internal designers at the organisation who had their own design thinking methodology. Moreover, this PoC described a case of antagonist generativity with negative regeneration effects on the object and positive regeneration effects on the organisation.

What does this case allow us to learn about the method? Two reasons could explain the negative cognitive generativity. First, Sismo was confronted to a client organisation with a deep theoretical knowledge and a different vision of the design carried by the internal designers for whom the PoC questioned their practise. Then, the original question was not an open question but a closed one (finding a usage to transition in flooring) prefiguring from the beginning where they wanted to go and leaving little room for questioning the question by Sismo. Nevertheless, the case shows that even in difficult conditions, the Sismo method has results: the PoC is an opportunity to put the actors in an unusual situation in relation to the question of innovation and it brings the opportunity to bring in the design new third parties (architects).

Study case n°10

Initial context

Organisation: The client organisation is a B2B2C materials manufacturer and distributor with deeply R&D. The sale of its products is done through other companies or brands such as company X with which they have a purely commercial relationship. In addition, they do not have privileged access to the users of their products.

Object: The major technological-oriented innovations have already been made, today their main challenge was to clarify their product lines to allow mass distribution. Even though they were in a quasi-monopoly position, the company was losing market share, especially due to the lack of awareness of the company's know-how and product quality.

Presentation of the project

The ambition of the client was then to make its products better known to the general public. Their attention particularly focused on enhancing the value of windows in sales experience. The project that won Sismo started with observations in stores around France with marketers from the client organisation and two co-creation workshops. The first workshop took place with users and the second with sellers. For each workshop, a part of the project team from the client organisation was present. The involvement of the project team was part of the design brief. The scriptwriting that was then developed was based on the idea to move from a technical vocabulary with a broad range of products to comfort concept. This paradigm shift that took shape in devices around the sales route should have helped sellers to better embrace him/herself the client's product value and then facilitate communication with clients and sales. The idea was to balance between a theoretical approach through informative devices and a sensory

approach through devices that involve the body senses to help clients better embrace and feel the comfort concept. Some devices were dedicated to showroom and others to roaming.

Characteristics of the PoC

A PoC was conducted to test, in the one hand, the appropriation of the new devices by the sellers and on the other hand, the comprehension of the products by the customers. The goal of the PoC was also for the client a way to consolidate its partnership with its sellers that was previously only a commercial relationship. The PoC took place in December 2018 and lasted one month in a showroom store. The main people involved during the PoC were two marketing managers from the client organisation and the salesman.

Design of the PoC

The devices were designed by the Sismo team of an engineer and an industrial designer. A lot of time was needed for the client organisation to find a sales partner who wanted to take part in the PoC. It induced a long period between the scriptwriting and the launch of the PoC (about 3 months) when a great refinement of devices was performed following two meetings with the client. The devices were then manufactured by a subcontractor. Moreover, a kit was developed for the seller to explain the goal of the PoC and give guidelines for observations and interviews.

Setup and animation of the PoC

The devices were setup in the showroom store that belonged to the seller and made available to the seller for roaming. Moreover, the seller was trained by the Sismo team to take control of devices and how to retranscribe information collected during observations and interviews.

The Sismo team went with the seller during the first sales. The Sismo team spent three days at the showroom and one day on roaming where they could have made few observations because of low attendance. Observations and interviews allowed Sismo team to collect reactions from the seller. The observed gestures, looks, body postures and speech of the seller allow them to improve continuously the devices and their use. For instance, the card game that was developed to better evaluate clients need was only used once because he wanted “to stay serious”. However, this one use allowed to observe a usage of the card game that had not been foreseen. From the point of view of the client, people were very sensitive to physical experience to “have a real evidence” of the comfort. After this 5-day animation, the seller was left in autonomy during three weeks with the kit. Two new days of support were planned but the seller did not re-manifest himself.

Review and rest of the PoC

Learning process was restricted, and few iterations were generally performed, especially because few clients had been met during the animation period probably due to period of the year. These minor iterations are linked to high level of finish and detail of the tested devices. Two reasons can be suggested: (1) an extended design period with customer returns and (2) the difficulty to deliver things still under construction. According to Sismo’s designer: “My PoC was not dirty enough [...] I regret to have provided a thing too finished, too clean. I think it’s related to my distortion of industrial designer and my young experience, I did not want something that makes us blush!”

During the absence of Sismo, the seller used only very few devices because he did not think he needed to use it because he was a very good seller. It is also the way the network animator of Company X described him. However, when the PoC was over, he deeply wanted to keep two devices. This B2B2C context raised additional difficulties for the PoC. First, it took a long time

to find a seller, then the client organisation could not force the seller to provide observation and interview feedback to Sismo (that he did not do it) and according to Sismo's designer, it "asked twice as much work". Moreover, a point of divergence between the client organisation and the seller that was not compensate for the time and the risk quickly ended the collaboration and thus the access to the field and clients. The PoC allowed, on the one hand, to engage in a pilot phase with new seller partners that will begin after a new scriptwriting phase, and on the other hand, to absorb other projects in the company.

Findings

This case was interesting to investigate because the client organisation was a B2B2C company and the PoC induced new types of relationships with its sellers and allowed the company to interact with its users. Moreover, this PoC described a trend that has only been observed once: a positive regeneration effects on the object and a negative regeneration effects on the organisation.

What does this case allow us to learn about the method? The main difficulty of this PoC was to find a company and a seller who would like to welcome the PoC, which can be explained by the innovative aspect for them of this type of approach. In particular, this made the PoC rest on a single seller who was a very talented one. Thus, the choice of the seller was probably not the most appropriate to maximise learning. Although not retranscribed in the quantitative study, organisational learning took place (after the PoC) and was notably induced by the bad course of the PoC in terms of relationships. In addition, Sismo's project manager questioned the in situ nature of the PoC because according to him, it did not allow to maximise cognitive learning on the object.

CONCLUSION AND DISCUSSION

The purpose of this paper was to investigate two research questions: (RQ1) Is a PoC generative in both cognitive and social aspects? and (RQ2) What are the methods to reach this potential generativity?. The study was performed in the context of the intervention research at Sismo, a French independent design and innovation agency, internationally recognised for its expertise in PoC. This paper has allowed to validate the hypotheses (H1, H2) and to enrich the hypotheses (H3, H4). The last hypothesis (H5) about the ability of designers to overcome cognitive and organizational biases could not have been instigated as hoped.

The main result of this study is that Sismo perform PoCs that are certainly 'validation' but which also carries double generativity. In addition, this study provided important clarification; this generativity is rather stronger on the organisation than on the object, which Sismo finally evaluates quite 'as expected' after the PoC. This method is geared to this end, namely to maximise learning especially organisational, put the 'buyers of the PoC' in action, push them to make discoveries by themselves and discover themselves.

A PoC with double generativity corresponds to the demand of many innovation processes, therefore there is no surprise that they have spread everywhere. Moreover, it is important to note that the PoC is not necessarily the best in-house tool to a team – the PoC is especially useful when it is necessary to change the actors carrying the project (new entrant, new 'buyer', new funder, ...). Thus, if we see PoCs appear within organisations, it is especially the symptom that the project must convince internally, that the mobilisation of the organisation is not acquired – which allows us to confirm a whole literature on intra-organisational tensions

around innovation. Finally, in terms of methods, the method put in place requires a talent to involve actors to help them change and change their organisation. Insofar as Sismo is external to the organisation, they identify the operating biases of the organisation and they propose alternative ways of working, they behave like action learning researchers.

CONTRIBUTION TO THE FIELD

This study contributes to four fields:

- (1) literature on PoCs: PoCs have a dual nature – not only validation but also generativity;
- (2) innovation ecosystems: PoCs are critical media to create a generative ecosystem (help actors to collaborate in the unknown, help to involve new actors, help to discover and learn together);
- (3) innovation management and NPD: PoCs are a way to overcome the intra-organisational tensions around innovation – they help the actors revise their a priori, renew their competences, discover their design capacities –, in that sense a PoC is a great tool to support ‘dynamic capabilities’;
- (4) management in general: PoC can be understood as action learning.

MANAGERIAL IMPLICATIONS

This study can, not only help PoC designers, but also PoC ‘buyers’ and/or ‘users’ by knowing what one can expect. This study also provides a tool for all managers in charge of exploring the unknown and needing a technique to support their action and help them involve new partners.

REFERENCES

- Akrich, Madeleine (1987). Comment décrire les objets techniques?. *Techniques et culture* 9: 49-64.
- Amabile, Teresa M. (1998). *How to kill creativity*. Vol. 87. Boston, MA: Harvard Business School Publishing.
- Bendavid, Ygal, and Cassivi, Luc (2012). A ‘living laboratory’ environment for exploring innovative RFID-enabled supply chain management models. *International Journal of Product Development* 17.1-2: 94-118.
- Callon, Michel (1986). *The sociology of an actor-network: The case of the electric vehicle*. Mapping the dynamics of science and technology. Palgrave Macmillan, London, 19-34.
- Carsten, Bruce (1989). *Carsten’s Corner. Power Conversion and Intelligent Motion*.
- Cartwright, M. E., Cohen, S., Fleishaker, J. C., Madani, S., McLeod, J. F., Musser, B., & Williams, S. A. (2010). Proof of concept: a PhRMA position paper with recommendations for best practice. *Clinical Pharmacology & Therapeutics*, 87(3), 278-285.
- Christiansen, John K. and Gasparin, Marta (2017). How experiments in the fuzzy front end using prototyping generates new options.
- Cooper, Robert G. and Sommer, Anita F. (2016). The agile–stage-gate hybrid model: a promising new approach and a new research opportunity. *Journal of Product Innovation Management* 33.5: 513-526.
- Dubois, Louis-Etienne, Le Masson, Pascal, Weil, Benoît, and Cohendet, Patrick (2014). From organizing for innovation to innovating for organization: how co-design fosters change in organizations. *AIMS* 2014.
- Eisenhardt, Kathleen M. and Graebner, Melissa E. (2007). Theory building from cases: Opportunities and challenges. *Academy of management journal* 50.1: 25-32.
- Gay, Claudine and Szostak, Bérangère (2017). *Management de l’innovation: Nouveaux enjeux et défis, Méthodes faciles à appliquer, Illustrations et témoignages récents*. Dunod.
- Hatchuel, Armand, and David, Albert (2008). Collaborating for management research, from action research to intervention research in management. In A. B. Shani, S. A. Mohrman, W. A. 143-162.
- Hatchuel, Armand, Le Masson, Pascal, Reich, Yoram, and Subrahmanian, Eswaran (2017). Design theory: a foundation of a new paradigm for design science and engineering. *Research in Engineering Design*, 29(1), 5-21.
- Hatchuel, Armand and Weil, Benoît (2009). CK design theory: an advanced formulation. *Research in engineering design* 19.4: 181.
- Hogue, Teresa (1993). *Community-based collaboration: Community wellness multiplied*. Oregon Center for Community Leadership, Oregon State University.
- Hooge, Sophie, Béjean, Mathias, and Arnoux, Frédéric (2017). Organising for radical innovation: The benefits of the interplay between cognitive and organisational processes in KCP workshops. *The Role of Creativity in the Management of Innovation: State of the Art and Future Research Outlook*. 205-237.

- Fabien, Jean (2016). L'échange génératif de technologies innovantes : engagement conceptif et conception de la valeur. Gestion et management. PSL Research University.
- Le Masson, Pascal, Hatchuel, Armand, and Weil, Benoit (2009). Design theory and collective creativity: a theoretical framework to evaluate KCP process. DS 58-6: Proceedings of ICED 09, the 17th International Conference on Engineering Design, Vol. 6, Design Methods and Tools (pt. 2), Palo Alto, CA, USA, 24.-27.08. 2009.
- Mankins, John C. (1995). Technology readiness levels. White Paper, April 6: 1995.
- Mer, Stéphane, Jeantet, Alain, and Tichkiewitch, Serge (1995). Les objets intermédiaires de la conception: modélisation et communication. Le communicationnel pour concevoir: 21-41.
- O'Connor, Gina C. (2008). Major innovation as a dynamic capability: A systems approach. Journal of product innovation management, vol. 25, no 4, p. 313-330.
- Park, Gyung-Jin (2007). Analytic methods for design practice. Springer Science & Business Media.
- Paulus, Paul B., Putman, Vicky L., Dugosh, Karen L., Dzindolet, Mary T., and Coskun, Hamit (2002). Social and cognitive influences in group brainstorming: Predicting production gains and losses. European review of social psychology 12.1: 299-325.
- Radaelli, Giovanni, Guerci, Marco, Cirella, Stefano, and Shani, Abraham B. (2012). Intervention research as management research in practice: learning from a case in the fashion design industry. British Journal of Management, vol. 25, no 2, p. 335-351.
- Sadin, Stanley R., Povinelli, Frederick P., and Rosen, Robert (1989). The NASA technology push towards future space mission systems. Space and Humanity. Pergamon, 1989. 73-77.
- Subrahmanian, Eswaran, Eckert, Claudia, McMahon, Christopher, and Reich, Yoram (2017). Economic development as design: Insight and guidance through the PSI framework.
- Suh, Nam P. (1999). Applications of Axiomatic Design. Integration of Process Knowledge into Design Support Systems. Springer, Dordrecht, 1999. 1-46..
- Yin, R. K. (2003). Case Study Research: design and methods, Thousand Oaks, 3.
- Yu, Fei, Pasinelli, Michele, and Brem, Alexander (2018). Prototyping in theory and in practice: A study of the similarities and differences between engineers and designers. Creativity and Innovation Management 27.2: 121-132.

APPENDIX

Table 3: Presentation of selected PoC cases

Code	Client	Description of the project	Year/ Month of PoC execution	Method
C1	Economic hotel chain	Imagining new experiences in common spaces to attract new customers, especially among millennials	16/02	Longitudinal study
C2	Supermarket group	Developing a concept to help transport heavy items in stores	16/09	Longitudinal study
C3	Governmental employment agency	Designing a new agency model to foster social dialogue and accelerate the return to work	17/03	Longitudinal study
C4	Brand of holiday villages	Proposing new hospitality and customer advice regarding a digital platform	17/03	Longitudinal study
C5	Tire manufacturer	Designing a common place for all IT support teams in the company	17/09	Longitudinal study
C6	Aparthotel chain	Rethinking the common spaces to re-enchant the customer experience	17/10	Longitudinal study
C7	Tire manufacturer	Rethinking the hospitality experience in the new headquarters building under construction	17/11	Longitudinal study
C8	Flooring manufacturer	Designing new ranges and services of floor transitions	17/11	Longitudinal study
C9	Public transport operator	Rethinking the hospitality experience in station with a focus on the interactions on the counter – Part 1	18/07	Longitudinal study
C10	Materials manufacturer and distributor	Enhancing windows in sales experience to make the company's products more widely known to the general public	18/12	Longitudinal study
C11	Gambling company	Proposing a game concept that is on a daily shopping journey	18/12	Intervention research
C12	Public transport operator	Rethinking the hospitality experience in station with a focus on the interactions on the counter – Part 2	19/03	Intervention research

Table 4: Results of the quantitative study

Case	Role of project stakeholders (Form filled out with (W) or without (O) the presence of the author)	Answers to questions about cognitive generativity									Answers to questions about social/organisation generativity										
		1A	1B	2A	2B	3A	3B	4A	4B	Weighted Sum (A)	Weighted Sum (B)	5A	5B	6A	6B	7A	7B	8A	8B	Sum (A)	Sum (B)
C1	Co-founder (W) Middle manager (W) Deployment project manager (W)	3 4 3	3 4 3	5 5 4	5 3 4	5 2 1	3 2 1	5 1 1	4 1 1	12.7	10.7	4 5 3	5 5 5	3 1 1	5 3 2	3 1 3	4 3 4	2 2 1	4 4 3	9.7	15.7
	Average ± Standard deviation	5.0 ± 0.0	4.7 ± 0.6	4.7 ± 0.6	4.0 ± 1.0	2.7 ± 2.1	2.0 ± 1.0	2.3 ± 2.3	1.7 ± 1.7			4.0 ± 1.0	5.0 ± 0.0	1.7 ± 1.2	3.3 ± 1.5	2.3 ± 1.2	3.7 ± 0.6	1.7 ± 0.6	3.7 ± 0.6		
C2	Co-founder (O) Middle manager (W) Project manager (W)	5 4 5	5 2 5	2 3 4	4 3 4	5 1 3	1 1 0	5 1 2	5 1 5	12.1	11.2	5 4 4	5 3 4	2 1 3	2 3 3	0 1 1	0 2 2	1 1 1	1 2 3	8.0	10.0
	Average ± Standard deviation	4.7 ± 0.6	4.0 ± 1.7	3.0 ± 1.0	3.7 ± 0.6	3.0 ± 2.0	0.7 ± 0.6	2.7 ± 2.1	3.7 ± 2.3			4.3 ± 0.6	4.0 ± 1.0	2.0 ± 1.0	2.7 ± 0.6	0.7 ± 0.6	1.3 ± 1.2	1.0 ± 1.0	2.0 ± 2.0		
C3	Co-founder (W) Project manager (W) Technical expert (W)	5 5 5	5 5 5	4 5 5	4 4 5	4 2 3	4 3 3	3 2 5	3 3 5	14.7	15.3	2 5 4	3 5 5	3 2 3	3 3 3	1 2 2	2 4 4	2 1 2	5 3 2	9.7	14.0
	Average ± Standard deviation	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.6	4.7 ± 0.6	4.3 ± 1.0	3.0 ± 0.6	3.3 ± 1.5	3.7 ± 1.2			3.7 ± 1.5	4.3 ± 1.2	2.7 ± 0.6	3.0 ± 0.0	1.7 ± 0.6	3.0 ± 1.2	1.7 ± 0.6	3.3 ± 0.6		
C4	Co-founder (O) Project manager (O) Technical expert (W)	4 4 3	3 4 4	5 4 4	4 3 3	5 2 1	5 2 1	4 3 2	4 3 2	12.9	12.1	4 5 3	5 5 5	3 1 1	5 3 2	3 1 3	4 3 4	2 2 1	4 4 3	9.0	12.7
	Average ± Standard deviation	4.0 ± 0.6	3.7 ± 0.6	4.3 ± 0.6	3.3 ± 0.6	2.7 ± 2.1	2.7 ± 2.1	3.0 ± 1.0	3.0 ± 2.0			4.0 ± 1.0	5.0 ± 0.0	1.7 ± 1.2	3.3 ± 1.5	2.3 ± 1.2	3.7 ± 0.6	1.7 ± 0.6	3.7 ± 0.6		
C5	Middle manager (W) Project manager (W) Technical expert (W)	4 4 5	3 3 5	5 5 3	5 5 3	0 4 2	0 4 1	0 5 3	0 4 2	11.9	10.1	2 5 3	3 5 5	2 2 0	2 3 3	0 2 3	1 4 4	1 1 1	2 2 2	7.3	12.0
	Average ± Standard deviation	4.3 ± 0.6	3.7 ± 1.2	4.3 ± 1.2	4.3 ± 1.2	2.0 ± 2.0	1.7 ± 2.1	2.7 ± 2.5	2.0 ± 2.0			3.3 ± 1.5	4.3 ± 1.2	1.3 ± 1.2	2.7 ± 0.6	1.7 ± 1.5	3.0 ± 1.7	1.0 ± 0.0	2.0 ± 0.0		
C6	Co-founder (W) Co-founder (W) Project manager (W) Technical expert (O)	5 5 5 5	5 4 4 5	5 1 3 5	3 4 3 4	5 5 2 2	5 5 1 2	5 2 2 3	5 3 2 2	13.8	13.3	2 5 4 3	5 4 5 5	2 0 3 3	4 3 4 3	0 3 2 0	2 4 3 2	2 4 3 2	4 3 4 4	10.0	15.0
	Average ± Standard deviation	5.0 ± 0.0	4.5 ± 0.6	3.5 ± 0.6	3.5 ± 1.0	3.5 ± 2.1	3.3 ± 1.0	3.0 ± 2.3	3.0 ± 1.7			3.7 ± 1.3	4.7 ± 0.5	1.7 ± 1.4	3.7 ± 0.6	1.7 ± 1.5	3.0 ± 1.0	3.0 ± 1.0	3.7 ± 0.5		
C7	Co-founder (W) Project manager (W) Technical expert (W)	5 4 5	4 4 3	3 4 4	3 4 3	5 3 1	4 3 0	3 1 2	4 4 1	9.8	10.0	4 3 3	4 5 3	3 1 1	3 2 1	2 1 4	2 2 4	5 3 1	3 5 2	8.5	12.0
	Average ± Standard deviation	4.5 ± 0.7	3.5 ± 0.7	4.0 ± 0.0	3.5 ± 0.7	2.0 ± 1.4	1.5 ± 2.1	1.5 ± 0.7	2.5 ± 2.1			3.0 ± 0.0	4.0 ± 1.4	1.0 ± 0.0	1.5 ± 0.7	2.5 ± 2.1	3.0 ± 1.4	2.0 ± 1.4	3.5 ± 2.1		
C8	Middle manager (W) Project manager (W) Technical expert (W)	5 4 5	3 3 5	4 4 4	3 4 4	2 3 0	1 3 0	0 4 3	0 3 4	10.8	9.7	3 4 5	5 5 4	2 4 4	2 4 4	3 4 4	4 4 5	1 2 1	2 3 2	12.3	14.7
	Average ± Standard deviation	4.7 ± 0.6	3.7 ± 1.2	4.0 ± 0.0	3.7 ± 0.6	1.7 ± 1.5	1.3 ± 1.5	2.3 ± 2.1	2.3 ± 2.1			4.0 ± 1.0	4.7 ± 0.6	3.3 ± 1.2	3.3 ± 1.2	3.7 ± 0.6	4.3 ± 0.6	1.3 ± 0.6	2.3 ± 0.6		
C9	Co-founder (O) Middle manager (W) Technical expert (W)	5 3 3	2 4 5	4 4 5	2 4 5	5 1 5	3 1 5	1 5 5	1 3 5	15.5	12.8	2 5 3	3 5 3	0 3 2	1 3 2	2 3 1	2 4 2	5 4 3	5 4 3	11.0	12.3
	Average ± Standard deviation	4.3 ± 1.2	3.7 ± 1.5	4.3 ± 0.6	3.7 ± 1.5	3.7 ± 2.3	3.0 ± 2.0	3.7 ± 2.3	3.0 ± 2.0			3.3 ± 1.5	3.7 ± 1.2	1.7 ± 1.5	2.0 ± 1.0	2.0 ± 0.1	2.7 ± 1.2	4.0 ± 1.0	4.0 ± 1.0		
C10	Middle manager (W) Project manager (W) Technical expert (W)	4 4 4	2 4 4	3 5 2	2 4 2	1 1 3	2 3 3	1 1 4	2 2 5	9.5	11.5	3 3 3	1 1 3	0 0 1	1 1 1	1 3 4	2 3 4	3 2 2	2 2 2	8.3	7.7
	Average ± Standard deviation	4.0 ± 0.0	3.3 ± 1.2	3.3 ± 1.5	3.3 ± 1.2	1.7 ± 1.2	2.7 ± 0.6	2.7 ± 1.7	3.0 ± 1.7			3.0 ± 0.0	1.7 ± 1.2	0.3 ± 0.6	1.0 ± 0.0	2.7 ± 1.5	3.0 ± 1.0	2.3 ± 0.6	2.0 ± 0.0		
C11	Middle manager (W) Project manager (W) Technical expert (-)	3 4 3	3 4 3	4 2 4	3 5 3	2 2 3	2 4 2	1 3 2	2 4 3	10.0	12.3	5 3 4	5 2 4	3 4 1	2 3 2	4 2 2	4 3 3	1 1 1	3 3 3	10.3	12.3
	Average ± Standard deviation	3.3 ± 0.6	3.3 ± 0.6	3.3 ± 1.2	3.7 ± 1.2	2.3 ± 0.6	2.7 ± 1.2	2.0 ± 1.0	3.0 ± 1.0			4.0 ± 1.0	3.7 ± 1.5	2.7 ± 1.5	2.3 ± 0.6	2.7 ± 1.2	3.3 ± 0.6	1.0 ± 0.0	3.0 ± 0.0		
C12	Co-founder (O) Middle manager (O) Project manager (W) Technical expert (-)	5 4 4 4	4 3 3 2	5 4 5 4	4 4 5 4	5 1 3 3	3 2 5 2	3 3 1 1	3 3 1 3	12.1	12.2	3 5 3 4	3 5 5 5	1 3 1 1	2 4 2 2	2 4 2 2	3 4 4 3	5 4 2 5	5 4 5 5	11.7	15.3
	Average ± Standard deviation	4.3 ± 0.5	3.0 ± 0.8	4.5 ± 0.6	4.3 ± 0.5	3.0 ± 1.6	3.0 ± 1.4	2.0 ± 1.2	2.5 ± 1.0			3.7 ± 1.0	4.3 ± 1.0	1.7 ± 1.0	2.7 ± 1.0	2.7 ± 1.0	3.7 ± 0.6	3.7 ± 1.4	4.7 ± 0.5		