Role of boundary objects in the coevolution of design and use: the KMP experimentation

Amandine PASCAL

University of Nice – Sophia Antipolis
Research Laboratory GREDEG UMR 6227, CNRS – UNSA
250, rue Albert Einstein, Bt. 2 – 06560 SOPHIA ANTIPOLIS VALBONNE
Phone : +33 4 93 95 43 96 ; Fax : +33 4 93 65 37 98
email: pascal@gredeg.cnrs.fr

Catherine THOMAS

University of Metz
Research Laboratory GREDEG UMR 6227, CNRS – UNSA
email: thomas@gredeg.cnrs.fr

Introduction

Nowadays, it is widely recognized that an ICT tool cannot be built without knowing who will use it and what they will do with. In this perspective, Human-Computer Interaction community (Carroll 1990; Jarke, Tung Bui and Carroll 1998; Young and Barnard 1987; Young *et al.* 1989) developed a scenario-based approach contrasting with the traditional information system design. The scenario describes an existing or envisioned system from the perspective of one or more users and included a narration of their goals, plans and reactions (Rosson and Carroll 2002). As a result, design is founded on the use of scenarios as a central representation for analysis and design of use. The scenario-based design appeares to be a first step in the integration of users in the design of ICT tool. However, we would like to underline in this paper a more active role of users in the design process.

According to Orlikowski (2000) while a technology can be seen to have been constructed with particular materials and inscribed with developers' assumptions and knowledge about the world at a point in time, it is only when this technology is used in recurrent social practices that it can be said to structure user's action. The use of technology in recurrent social practices must be considered because how technological properties will be used or appropriate for the moment is not inherent or predetermined. This approach leads us to dissociate the designers' world from the users' world. In this perspective, the design project is the result of the co-evolution and the convergence of both worlds: on the one hand, the world of design and a first integration of users by scenarios; on the other hand, the world of users where innovation is the art of interesting an increasing number of allies who will make the world of design stronger and stronger (Akrich *et al.* 2002).

The objective of this paper is to understand the mechanisms of interaction between the world of design and that of users i.e. between loops of co-design and loops of uses. In this perspective, the success of an innovation may be explained by the co-evolution and the convergence of these two worlds. In this process, we suggest that boundary objects play a key role in the convergence of these two worlds.

In order to demonstrate this proposal our article will lean on a specific design research conducted five years ago: the Knowledge Management Platform project (KMP project). The KMP project aimed to build a semantic web service of competencies in order to enhance exchange and combination dynamics of knowledge within the Telecom cluster of Sophia Antipolis (Alpes-Maritimes, France) thanks to an interactive mapping of competencies. Indeed, this cluster had to face two main problems due to its specific multi-technological activity (micro-electronics, information technology and telecommunications): on the one hand, a problem of knowledge visibility and, on the other hand, a problem of missing link among widely distributed types of knowledge within the cluster. This project wins hands down from practitioners. At the present time, both practitioners and the PACA region support it and set it up in a pre-industrialization phase. In this perspective, we can say that this project is a successful design research, having produced actionable knowledge.

The argument is organized as follows. First, we explore design research methodologies in management studies and more specifically recent developments of ICT tools building. Indeed, designing an ICT solution requires a specific attention on use. The argument then turns to the KMP experimentation. Finally, we expose and discuss the KMP results. This discussion focuses on the emergence and the development of boundary objects, and their role in the coevolution of both designers' world and users' one.

1. The design methodology: an iterative process of co-designing

Design methodologies are specific modes of engaging in research. Especially, they are characterized by an active intervention process in the system in which the researchers act. Because academic studies propose distinct views on intervention process and address the issue of the model of intervention, we have chosen to construct our design methodology on two parts. Firstly, we focus on design research methodologies in order to identify the main steps for the intervention process. Secondly, we discuss the process of design in the specific case of an ICT solution.

1.1. The process of design methodology: its main steps

In this part, we discuss to different but complementary process design approaches which focus on a specific aspect of the intervention process: those of Hatchuel and Molet (1986) which are more practitioner oriented and those of Romme and Endenburg (2006) which are more theoretically oriented.

1.1.1. The intervention process: Hatchuel and Molet (1986)

Hatchuel and Molet (1986) have distinguished five phases in the intervention process:

(i) *The "feeling of discomfort":* this step could also be called the perception of the issue. During this step, researchers and practitioners co-construct the issue. There is a confrontation between the researcher's theoretical concepts and the empirical issue.

(ii) *Building a 'rational myth':* it consists of the transformation of perceptions into concepts and data and of elaborating a theoretical model that allows the intervention.

(iii) *The experimental phase: intervention and interaction*: the two preceding steps enable to insert a new stimulus into the organization. During this experimental step, practitioners' reactions can induce modifications of both the tool and the organization.

(iv) *The inductive phase: portraying a set of logics.* It consists in creating a learning process both for the researchers and the different practitioners about the organization's local logics.

(v) *The change process: knowledge versus implementation.* This process induces, thanks to the implementation of the tool, the crossed transformation of the organization and the tool and the development of knowledge on these two levels. It also allows a return, in a constructive way, to a new understanding of the first phase i.e. the perception of the issue.

According to the writers' point of view, intervening in an organization requires five steps that serve as guidelines for the researcher. These steps reveal in fact that the intervention calls for two main phases: firstly, to co-construct the issue with the practitioners with huge references on theory; secondly, to elaborate a tool that will support the intervention process.

However, the link between these two main phases is not clearly explained. We propose now to refer to Romme and Endenburg (2006) in order to enrich the comprehension of the link between the concrete research project and the theory and/or the previous studies.

1.1.2. The design process: Romme and Endenburg (2006)

Romme and Endenburg (2006) suggest a science-based approach to organization design in five components:

(i) *Organization science* is "the cumulative body of key concepts, theories, and experientially verified relationships useful for explaining organizational process and outcomes" (Romme and Endenburg 2006: 288). As such, these chunks of general knowledge provide the theoretical foundation for construction principles.

(ii) *Construction principles* are a "set of imperative propositions, grounded in the state-of-the-art of organization science" (Romme and Endenburg 2006: 288). They serve as a body of knowledge that will guide the elaboration of design rules and so the specific design process at hand. Consequently, construction principles serve to bridge the descriptive nature of scientific propositions and the prescriptive nature of design rules. Obviously, as the set of construction principles may be borrowed from different subfields, it is important to establish that this set is coherent.

(iii) *Design rules* are a "set of detailed guidelines for designing and realizing organizations, grounded in a related set of construction principles". In other words, design rules are "elaborate solution-oriented guidelines for the design process" (Romme and Endenburg 2006: 288). Hence, they collectively constitute a scheme for the design and may therefore be developed as a coherent set of related rules. In a closer approach, Van Aken (2004; 2005) proposes the concept of 'technological rules', which he defined as "a chunk of a general knowledge linking an intervention or artifact with an expected outcome or performance in a certain field of application" (Van Aken 2005: 23). In his definition, Van Aken specifically uses the term 'general' in order to stress the idea that it is not a specific solution or a specific situation, but a general prescription for a class of problems. For that reason, we may say that a technological rule is a "mid-range theory", whose validity is limited to a certain application domain. In the management field, these rules are not algorithmic but heuristic (Van Aken 2004).

(iv) *Organization design* is the "developing representations of the intended organizational system being (re)designed with help of the design rules" (Romme and Endenburg 2006: 289). Thereby, organization design is resulting from the interaction between design rules, the contingencies of the organization and so of the design situation, and at least the preferences of the people engaging in the organization design effort. We may notice here that organization design can be a specific solution or an artifact.

(v) *Implementation and experimentation:* during this step, the organization design or the artifact is implemented and the researcher evaluates the processes caused by that design.

According to Hatchuel and Molet (1986), Romme and Endenburg (2006) stress the fact that the whole system ought to be regulated through a set of feedbacks. However, because they suggest preceding the design step by specifying what they call "construction principles" and "design rules", these two authors offer a real complementary view.

1.2. Designing an ICT solution: a uses approach

This section expresses in more detail the design process of an ICT solution. By the way, it explores the interaction between technology and social system, i.e. uses. This question is a fundamental one in the IS (Information System) literature. IS studies generally reflect a particular position on this question (Orlikowski and Iacono 2001), oscillating from a technological position (technological determinism, discrete-entity tool view, autonomous technology) to a social one (strategic choice view, web-based ensemble models). We are favoring conception of the link between technologies and organizations that are more middle-ground approaches as reflected in emergent perspective and socio-technical one. From this point of view, we discuss in this section two main approaches: the structuration theory of technology (Orlikowski 2000) and the actor-network theory (Akrich *et al.* 2002).

1.2.1. A practice lens for studying the use of technology: Orlikowski (2000)

The structurational perspective of technology (Orlikowski 2000; DeSanctis and Poole 1994) is deeply rooted in the works of Giddens (1984). As we have previously seen, this emergent perspective takes a middle-ground position in the IS debate on the link between technologies and organizations. From this point of view, these works give a specific and stimulating definition of technologies and uses.

According to Orlikowski (2000), technologies present two distinctive aspects: the technology as artifact and the use of technology.

- Firstly, technology may be define as a technical artifact, which has been constructed with particular materials and inscribed with developers' assumptions and knowledge about the world at a point in time. These features are coupled with the spirit of technology, which is defined as "the general intent with regard to values and goals underlying a given set of structural features" (DeSanctis and Poole 1994: 126).
- Secondly, technology may be termed a technology-in-practice, which refers to the specific structure routinely enacted by individuals as they use the artifact in recurrent ways in their everyday situated activities. In that sense, technology-in-practice may be defined as the set of rules and resources enacted by the users of technology in their recurrent social practice.

This double acceptation of technology has several main consequences (Orlikowski 2000):

– While technology may be defined as a set of physical properties developed by designers, it is only when this technology is used in recurrent social practices that it structures human action.

– When users choose to use a technology, they are also choosing how to interact with that technology. From this point of view, users may, deliberately or inadvertently, use it in ways not anticipated by the developers. The physical properties inscribed in the artifact don't predetermine use of technology. Thus, *"use of technology is not a choice among a closed set of predefined possibilities, but a situated and recursive process of constitution, which may also and at any time ignore such conventional uses or invent new ones*."

- Use of technology is heavily influenced by the users' understandings of the properties and features of a technology, and these understandings are in turn strongly influenced by the images, descriptions, rhetorics and ideologies enacted by individuals belonging to different contexts.
- Finally, technology-in-practice is a kind of structure situated in the structural properties of social systems. Thus, in interacting with a technology, users mobilize many structurals, those borne by the technology itself, and those deriving from different contexts (group, community, organization, company, etc.) in which their usages fit.

Therefore, these theoretical insights lead us to dissociate the designers' world from the users' world. Effectively, when they develop the artifact, designers enact a set of structural properties that give functionalities. Respectively, in their recurrent use of technology, users may enact technology-in-practice in ways no anticipated by developers.

Developing a method for designing an ICT tool with regard to the structurational theory also leaves us to have a specific concern on the interactions between the designers' world and the users' one. Furthermore, it underlines that technology-in-practice only occurs in recurrent social practices: consequently, users must have the technology as soon as possible in the design process.

1.2.2. The users' world: building a socio-technical network

Because they have a specific concern on the role of actors in the design process of an innovation, we mobilize the actor-network theory (ANT) for developing our methodology.

ANT has been used to investigate the success or the failure of a number of technological innovations. In their approach, these scholars criticized both the Schumpeterian model and its entrepreneur's role and the diffusion model of innovation: *"the bringing together of market and technology, through which both inventions and the outlets which transform them into innovations are patiently constructed, is more and more a result of a collective activity and no longer the monopoly of an inspired and dedicated individual*" (Akrich *et al.* 2002: 189). The key to innovation is thus *"the creation of a powerful enough consortium of actors to carry it through, and when an innovation fails to be taken up this can be considered to reflect on the inability of those involved to construct the necessary network of alliances (the socio-technical* *network) amongst the other actors"* (Tatnall and Gilding 1999: 961). Network is used in a special way to describe shifting alliances of both human and non-human actors. Innovation has a collective dimension in which users intervene, and is continuously transforming depending on actors who participate to the process of conception. The model of translation proposed (Latour 1986) in this approach maintains that the movement of an innovation through time and space is in the hands of the socio-technical network who may modify it, deflect it, betray it, add to it, appropriate it, or let it drop.

We think that this approach, also named model of interessement, is relevant for designing an ICT solution. On the one hand, it allows understanding the key to success in innovation: *"socio-technical compromises and negotiations are the two key notions which allow this work of mutual adaptation which commands adoption to be understood"* (Akrich *et al.* 2002: 211). In this approach, *"to adopt an innovation is to adapt it, and this adaptation generally results in a collective elaboration, the fruit of a growing interest"* (Akrich *et al.* 2002: 209). In other words, the success of an innovation depends on a process of adaptation-adoption depending on the socio-technical environment. This success also relies on the construction of a socio-technical network that will defend and support the process of innovation. This is also the active role played by spokespersons: *"the fate of innovation, its content but also its chances of success, rest entirely on the choice of the representatives or spokespersons who will interact, negotiate to give shape to the project and to transform it until a market is built"* (Akrich *et al.* 2002: 217).

One the other hand, this approach is fruitful by conceiving innovation as the result of a 'whirlwind' model, which allows the multiple socio-technical negotiations. In this schema, *"innovation continuously transforms itself according to the trials to which it is submitted i.e. the 'interessements' tried out. Each new equilibrium finds itself materialized in the form of a prototype which concretely tests the feasibility of the imagined compromise"* (Akrich *et al.* 213). Here, the first prototype is rarely the good one, several successive passes (loops) are generally essential.

1.3. The coevolution of design and use: an integrative methodology

The design methodology oriented uses we propose is finally based on two points: first, we introduce users in the designers' loops through uses scenarios. Second, we separate designers' world from users' world in order to better understand the emergence of uses in real work practices.

1.3.1. Building uses scenarios

Since the late 1980s, researchers in human-computer interaction (HCI) have used scenarios as an effective means to discover user needs and better embed the use of artifact in work processes. Thus, uses scenarios can be a means for designers to manage the task-artifact cycle in order to achieve greater usefulness and usability (Carroll *et al.* 1998). In the HCI field, uses scenarios may be defined as *"working design representation of user experiences with and reactions to system functionality in the context of pursuing a task"* (Jarke *et al.* 1998: 159). Scenarios focus on the interaction between a system and its environment. Actually based on the distributed cognition theory, uses scenarios often address a narrow work context: classroom, cockpit, and office …

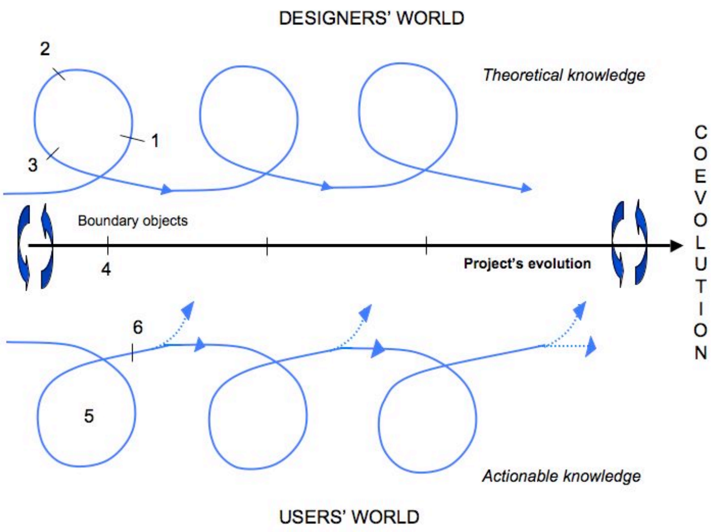
As we see above, structurational approach stresses the necessity to analyze interactions between actors and artifacts through organizational practices. Here, the relevant context is a wider one: the social system and its structural properties. Thus, we propose to complement interaction uses scenarios (HCI approach) with environmental uses scenarios (structurational approach). However, in order to achieve usability and moreover usefulness, uses scenarios are necessary but not sufficient. As structurational and socio-technical approaches emphasized, artifact must be placed in their real organizational practices, in other words, in the users' world.

1.3.2. An integrative uses oriented design methodology

According to the structurational approach, we propose to separate the designers' world from the users' world. The design process (designers' world) is composed of iterative loops (Akrich *et al.* 2002). Its main steps are based on the work of Hatchuel and Molet (1986) and Romme and Endenburg (2006) complemented with uses scenarios.

The users' world represents the socio-technical network that supports the process of innovation. Users-pilots (or lead users) are not the only components of this socio-technical network. As we see above, the success of a design project depends on the art of interessement i.e. to enlarge the socio-technical network.

Finally, in our methodology, the project results from the coevolution of these two worlds. We proposed to summarize this methodology as follows:



1: the feeling of discomfort

2: building a theoretical support

3: uses scenarios

4: building archetypes (boundary objects)

5: experimentation

6: the change process

Figure 1: An integrative uses oriented design methodology

To sum up, six main steps compose our design methodology:

1. The feeling of discomfort - to analyze the specific managerial problem to solve.
2. Building a theoretical support - as underlined by Romme and Endenburg (2006), this step consists in building construction principles and design rules.
3. Uses scenarios - based on distributed cognition and structurational approaches.
4. Building archetypes - in the specific case of an ICT tool design, these archetypes consist of the successive prototypes (including user interfaces) resulting form the coevolution of the designers' world and the users' one.
5. Experimentation - two complementary but no sequential phases composes this step: on the one hand, interesting a growing number of heterogeneous actors (users, professionals, bureaucrats, granters, …); here, spokespersons play a crucial role; on the other hand, evaluating the successive prototype. According to Jarke *et al.* (1998), a scenario-based evaluation can be used here. It means that the evaluation of the prototype will be based on the same theoretical framework that uses scenarios.
6. The change process - the adoption-adaptation process progressively spreads and transforms the organizational context. These transformations lead to an evolution of the managerial problem, which results in a new design loop. At the same time, these transformations modify the socio-technical network and may ensure its enlargement.

In our perspective, the prototype and, moreover, user interfaces can be viewed as boundary objects at the intersection of the designers' world and the users' one. Boundary objects may be defined as *"objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a* *common identity across sites … There have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation"* (Star and Griesemer 1989: 393). Thus, these boundary objects result from compromises and negotiations between designers and users; they allow the work of mutual adaptation i.e. the coevolution of both the designers' world and the users' one.

According to Star and Griesemer (1989), these boundary objects intersect two others worlds: both the theoretical and actionable knowledge worlds. In our point of view, boundary objects support the coproduction of these two kinds of knowledge and their coevolution.

2. The KMP Experimentation

This section describes the development and application of a uses oriented design methodology in the specific context of the KMP project.

2.1 The KMP project

This experimentation is located in the scientific park of Sophia Antipolis, on the French Riviera, which is "one of the most highly publicized technology parks which combine establishments of multinational corporations, small and medium-sized firms, and large public research centers and universities, under the auspices of public regional authorities" (Castells and Hall 1994: 85). Sophia Antipolis was created thanks to the support of state institutions, the high level of quality of life provided by the site and the settlement of prestigious engineering schools that have constituted a favorable basis to the development of new activities and to the settlement of new companies. Most of these companies were dedicated to ICT and Telecommunications activities. As Longhi (1999) noticed, Sophia Antipolis was a technopole created ex nihilo, without capitalization on strong industrial and / or university tradition. It is during the late 80's-early 90's that Telecom standardization organisms (such as the ETSI in 1988 and W3C in 1994) decided to locate their headquarters in Sophia Antipolis. As a consequence of their attractive power, the local Telecom cluster reached a "critical mass" level and high enough diversity to provide for the foundations of a true "innovative milieu", while the other poles (biotechnology and space) had not yet reached a similar development.

The shocks that characterized the early 1990s had a considerable impact on Sophia Antipolis. First, the shocks struck right at the heart of the project's growth engine, the computer science activities, that led to downsizing in large firms. Secondly, they raised important doubts on the validity of the project's development strategy, which was essentially a marketing strategy aiming at attracting investments from large firms and pointed out the lack of local synergies (Longhi 1999; Lazaric and Thomas 2005). Hence, several clubs and associations were created to facilitate exchanges, to study Technology Park's prospective, mainly in the ICT sector, and to implement collective innovation projects.

The main characteristics of the network dimensions in Sophia Antipolis in 2000 can be summarized in the following way:

- In the Sophipolitan "Telecom" Cluster, firms are evolving in a multi-technological context covering a wide range of industries from computing and multimedia to space, information processing, on-line services and networking, and microelectronics. We can notice the presence of a large number of famous French and foreign companies like Air France, Amadeus Development Company, Bouygues Télécom, ETSI, France Telecom, Matra Communication Sud, SEMA Group Télécom, Siemens, Atos Ingénierie Intégration …;
- Given the fact that parent companies are located elsewhere, the Sophipolitan cluster has always developed strong external links;
- It combines local and global dimensions in modular logics (indeed some of the cluster's firms produce products and / or services that are integrated in wider scale solutions);
- At the local level, the cluster's dynamics rely on the social interactions of several communities, associations, clubs etc., but revealing a lack of effective synergies.

At the beginning of the 2000's, it became crucial for firms not only to benefit from external links with partners and parent companies but also to establish strong regional links with local high-tech SMEs and key research institutes, in order to sustain innovative capabilities. The KMP Project launched in 2002 by Telecom Valley® (TV is a non profit association founded in 1991 by eight leading actors in telecommunications industry), is illustrative of this evolution.

- The objective of this project is to propose an innovative Knowledge Management Solution including a map of competencies of TV's actors in order to enhance exchange and combination dynamics of knowledge within the Sophia-Antipolis Telecom cluster. KMP is an experimentation of an ICT infrastructure, a web service of competencies. This prototype is a component of a web portal designed for TV members (companies, research and formation institutes involved in ICT domains).

2.2 The KMP methodology: the coevolution of design and uses

After a brief description of the main actors of the KMP project, we try out the process of the design methodology.

2.2.1 The main actors of the KMP project

Representatives from different academic fields composed the project team: economics and management - CNRS (GREDEG) and Telecom Paris (GET)-, computer science and ergonomics –INRIA-, telecommunication sciences -ENST Bretagne (GET)-.

Users were first represented by two commissions of TV (development and partners) and by pilot users. At the beginning of the project, 5 firms (Amadeus, Arianne II, France Télécom R&D, Hewlett Packard, Philips Semiconductors), one local development institute (CAD) and three research institutions (University of Nice, INRIA, GET) were pilot users. In 2003, when the design process of the artifact had really began, new pilots joined the project: IBM, ATOS Origin, Transitiel, Elan IT, Qwam System, Cross Systems and one local development institute (CCI-IRT). Then, others actors participated in the enlargement of the KMP socio-technical network without becoming pilot users: all TV members, club and association of Sophia Antipolis territory, ICT firms located outside the Sophia Antipolis territory.

In this perspective, users are not given *ex ante* but result from the permanent coevolution of the KMP project and the socio-technical network.

2.2.2 The KMP design methodology process

According to the design methodology previously presented (1.3.), the KMP design methodology process distinguishes the designers' world from the users' world and is composed by iterative co-designing loops (see figure 2).

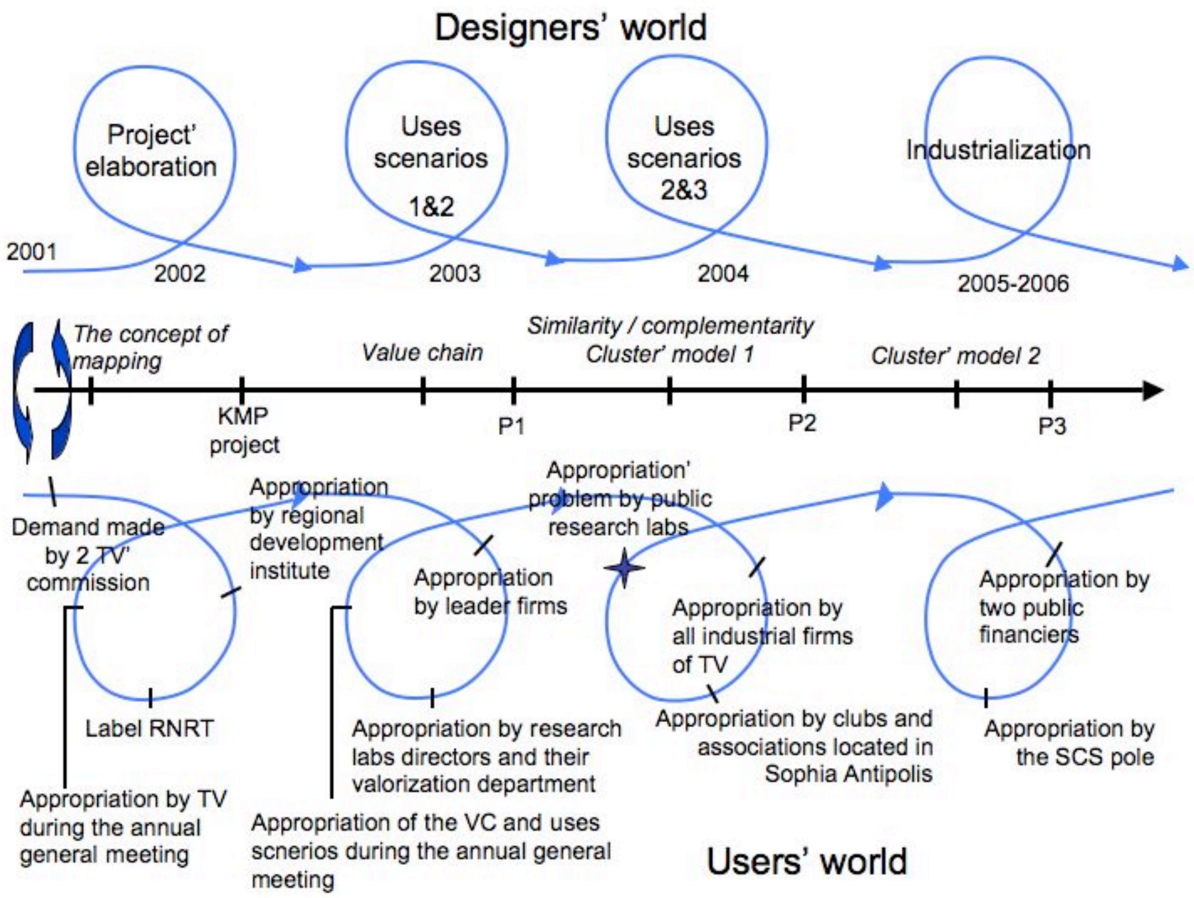


Figure 2: The KMP design methodology process

Four loops compose this project: the first concerns the elaboration of the project and the last the transition phase form the prototype to its industrialization. We describe now these four loops, with a specific focus on two years 2003 and 2004, which are the core years of the design process.

Loop 1 (2001-2002)

During this first loop, this design's team is constituted and the KMP project is elaborated.

1. **The feeling of discomfort:** due to the lack of local links between TV members, two managers of TV association departments (development and partner departments) require from researchers to build a map of competencies. This project interests both researchers from social sciences (management and economics) and computer science.

2. **Building a theoretical support:** the main theoretical field mobilized is the Knowledge Based View. In this field, the organizational knowledge creation is a process of social exchange and combination of knowledge (Kogut 2000). The negotiated environment

that a cluster represents is a privileged source of knowledge exchange and cluster structures also provide the stability that can foster collective learning and combinative capabilities. Indeed, many scholars stress the role of proximity (geographical, cognitive, organizational and social) in a cluster in order to foster innovation. These proximities facilitate previous conditions for organizational knowledge-creation (Nahapiet and Ghoshal 1998): (1) the opportunity to make exchange and / or combination, (2) the capacity to anticipate value created by exchange and combination, (3) the motivation to exchange and combine, (4) the capability to combine heterogeneous knowledge.

Based on these construction principles, we identify the following design rules:

- To identify the cluster capital of competencies and its interactions in order to enhance exchange and combination
- To use the KMP project development in order to foster social and cognitive proximities.

3. **Uses scenarios:** during this loop, we don't develop a prototype but only the project in a general terms. Thus, we don't realize uses scenarios.

4. **Building archetypes:** during this loop, we built the KMP project in order to respond to the RNRT' call (a French Telecom program called "Réseau National de Recherche en Télécommunication"). At this stage, we identify three main goals: (1) acquire and give a broader visibility of the Telecom Valley community, (2) search and exchange information in the case of inter-firm cooperation, (3) search and exchange information in the case of public research / private research cooperation. In order to meet all these goals, we decide to create a competency-mapping tool. This tool will be mobilized in three generic uses scenarios: (1) describe and storage its competencies, (2) provide structured overview over the actors and competencies in the TV cluster (cluster exploration), (3) look for a partner. 26 exploratory interviews serve to construct these scenarios.

5. **Experimentation:** The positive evaluation of RNRT offers a broader legitimacy to the project, which was adopted in 2002' annual general meeting of TV. At the same time, this project of mapping the territorial competencies was also adopted by regional development institutes which have become strong allies, increasing the project's legitimacy. During this loop, the concept of competencies map has constituted the *"lowest common denominator",* which satisfies the minimal demands of each stakeholder *"by capturing properties that fall within the minimum acceptable range of all concerned worlds"* (Star and Griesemer 1989: 404). In fact, at the moment, nobody knows how to build this map but

everyone, for different reasons, was interested in it. For example, some researchers were interested by developing a KM tool, others by analyzing the knowledge dynamic inside a territory. Concerning industrial managers some of them wanted this map in order to decrease their transactional costs, others to increase their R&D cooperation … Finally, the regional development institute requires this map to enhance the capacity and performance of cities and regions.

6. **The change process:** Once the first compromise has been realized about the projet, it is now necessary to build a more precise compromise in order to co-design the ICT solution.

Loop 2 (2003)

During the second loop, the designers' team develop the generic uses scenarios 1 and 2.

1. **The feeling of discomfort:** in 2003, two managerial problems arise. First, how to precisely describe competencies without disclosing strategic know-how? Second, how to resolve the lack of connection inside the cluster generated by a lack of identity and mutual understanding linked to the multi-technological context of this cluster? Indeed, the members of the telecom sophipolitan cluster don't have a clear representation of who they are: "there has always been an ambiguity on whereas Sophia is more telecoms or computer" (member of the TV board).

2. **Building a theoretical support** based on two main theoretical fields: on the one hand, the competency literature both in strategic and human resources, on the other hand, the Resource Based View. Many scholars stress the role of identity to stimulate organizational knowledge creation processes and to coordinate the behavior of its cluster's members (Dyer and Nobeoka 2000; Kogut 2000). Based on the literature, we identify two main construction principles:

   – To elaborate a competency model that allows to identify, compare and localize competencies distributed in a cluster. Both strategic and human resources literature shows that a competency is built upon four principles: finality, systemic composition, actionability and visibility.
   – To identify a shared common space in order to create an identity and then to foster combinative capabilities.

This leads us to build the following design rules:

– A competency can be defined as an *action* -actionable principle-, which mobilizes *resources* (technical, scientific and managerial) –systemic principle- to produce a *delivery* –visibility principle-, which creates value in a *business activity* –finality principle-. In other words, action, resources, delivery and business activity are the four categories that compose the model.

- According to Cook and Huggins (2003)[1], a cluster may be defined as *"geographically proximate firms in vertical and horizontal relationships involving a localised enterprise support infrastructure with shared development vision for business growth, based on competition and cooperation in a specific market field"*. Based on this definition, a cluster may be represented by its main value chain.

3. **Uses scenarios:** we have built two uses scenarios. The first focuses on competencies description and storage by TV members (firms)[2]. This scenario allows to contextualize the competency model. It shows that the appropriate level for describing competencies inside a cluster is a collective one (team competencies). It also outlines that the depth of description has to be flexible. The second one pays attention to the cluster exploration[3]. It shows that the actors' identification and their localization in the value chain have to be complemented by the identification of their cooperations.

4. **Building archetypes:** the use of a semantic web service allows to integrate a wide flexibility in the description of competencies. A semantic web is based on ontologies. Ontology defines words constituting the area in which the knowledge will be represented by the diverse actors involved (Gandon 2001). In our experimentation, ontology has a tree structure. Based on the competency model, specific ontologies for each category (action, resources, deliverable, business activity) are built. Ontologies are in abstract forms in their higher levels and become more and more concrete in their lowest levels. These ontologies ensure the description of competencies depending on actors' interests. The cluster model interface (i.e. the value chain) helps locate: (1) competency: the platform provides dynamic up-to-date cartography of the competencies available in TV and its complementary part i.e. the missing competencies; (2) actor: the platform assists the identification and characterization of the actors of the TV value chain; (3) interaction: the platform supports the detection of existing or potential interactions between the actors of the value chain.

5. **Experimentation:** evaluations have been conducted during 5 steering committees. These steering committees lead to the validation of the prototype 1 (based on scenario 1 and

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[1] "Geographically proximate firms in vertical and horizontal relationships involving a localised enterprise support infrastructure with shared development vision for business growth, based on competition and cooperation in a specific market field"

[2] 12 interviews have been conducted

[3] 7 interviews have been conducted

2) and to the interessement of a growing number of actors. During this year, the main leading firms of the cluster decide to integrate the project as pilot users (see 2.1.1). At the end of the year, 73 competencies have been registered by 9 pilot firms.

6. **The change process:** at the end of the year, during the annual general meeting of TV, all the firms were asked to position themselves on the value chain. As a result, members of TV (not only the pilot firms) adopted this value chain as their own. This share representation of the collective space helped reinforce the collective identity and influences the strategies of cooperation. Consequently, three main changes appeared:

a. An open access to the prototype to all members of TV resulting in an increasing real-world experiment: prototype 1 was finished and online by January 2004.
b. A collective building and maintenance of ontologies: as ontologies are vital at the scale of a cluster, playing their full role in allowing flexibility and interoperability, it was decided that ontologies would be built and populated through usage and not by some knowledge engineers.
c. The impact of the value chain on the growing interest of TV members left us to improve the scenario 2 (explore the cluster) in the next loop.

Loop 3 (2004)

In 2004, we improved the generic uses scenario 2 and developed the uses scenario 3 which resulted in the design of the prototype 2.

1. **The feeling of discomfort:** in 2004, three main problems arose:

a) The value chain did not represent all the actors of TV cluster.

b) The needs of actors to improve scenario 2 by analyzing the strength and weakness of the cluster and by designing collective strategy for cluster promotion and development.

c) The search and exchange of information in the case of inter-firms cooperations or public and private research cooperations (uses scenario 3); for example, information allowing to answer queries such as: "I am looking for a partner specialized in encryption algorithms, who has already been involved in joint-projects and has an ISO 9001 certification".

2. **Building a theoretical support:** according to regional economic studies, the main actors of a cluster are: firms, public research labs, support infrastructures. As specified by the Resource and Competency Based View, it is crucial to identify three kinds of competencies (relational, managerial, technical) in order to choose the good partner.

Finally, thanks to the cooperation theory (Richardson 1972), we need to distinguish complementary and similar competencies in order to better understand actors' interest to cooperate.

These principles are translated into the following rules:

- A cluster model may be built by combining principle 1 and 2 (see fig. 3). In this new representation, all members have to be represented depending on their main competencies: technical competencies (firms and public research labs), managerial competencies (e.g. consultants in the domain of law, finance, …), relational competencies (e.g. local development institutes or clubs and associations in charge of reinforcing exchange in the cluster).
- Competency description must include a description of the cooperations in which they are involved (these competencies represent relational competencies of partners).
- Thanks to our competency model, similarity is related to competencies sharing the same action and resources, whereas complementarity is about competencies sharing the same business activity.

3. **Uses scenario:** in 2004, 40 interviews were conducted (20 with public research labs, 20 with firms) in order to built uses scenarios 3. These scenarios allow to identify a plurality of queries when actors look for a partner. Thus, we distinguish two kinds of queries: simplified queries e.g. a partner possessing one technology; complex queries e.g. a query on a partner possessing two competencies and with each competency items specified. They also show the importance of ontology and the necessity to build a simple interface, which provides browsing capabilities for the ontologies.

4. **Building archetypes:** prototype 2 includes a new representation of the common space (the cluster model 1 – see figure 3), queries on partner looking for and complex algorithms providing clustering view to analyze the TV cluster. One of these views, called "technological pole", presents a set of grapes (corresponding to similar competencies) sharing the same technological field e.g. a view of the microelectronics pole. Another view, called "value chain", presents a set of grapes sharing the same business activity. In this case, each grape is composed of similar competencies. However, these grapes are distributed on different technological fields (e.g. technological poles) and so are complementary with each other (sharing the same business activity). The 3G mobile is an example of a value chain in the TV cluster.

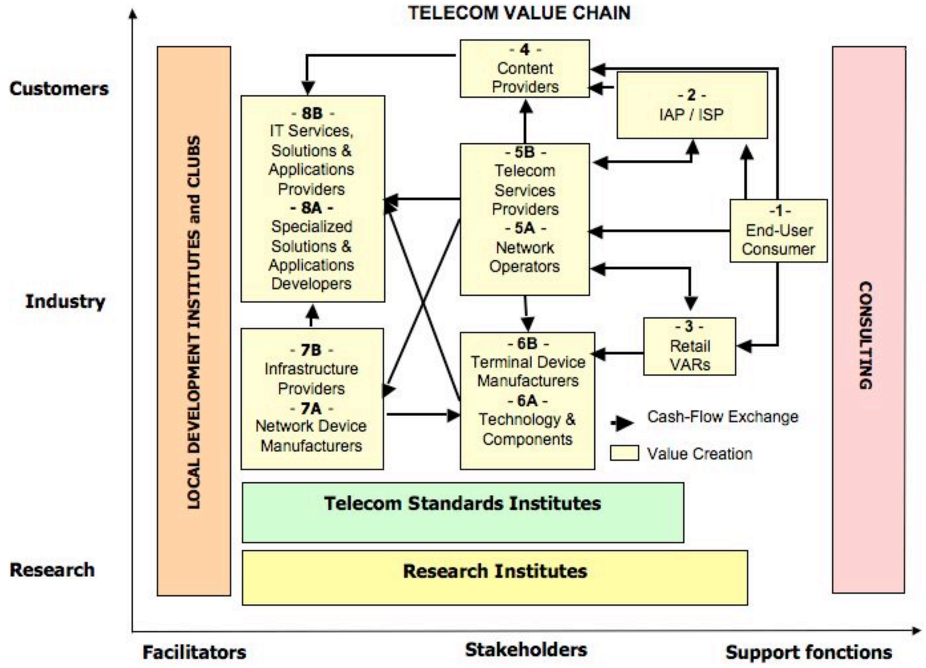

Figure 3: the cluster model 1

5. **Experimentation:** evaluations have been conducted during 4 steering committees and 12 interviews of evaluation based on the scenario approach. These committees and interviews, complemented by the real-world experimentation, give rise to three statements:

a) Firms and regional development institutes are still carrying the project. At the beginning of 2004, they look for new founders in order to industrialize it.

b) The interest of actors on the two concepts of similarity and complementarity enlarges the socio-technical network of TV by integrating others clubs and associations located in Sophia Antipolis. Thus, every club and association that aimed to enhance synergies within the whole sophipolitan cluster has been mapped. Some were classified as aiming to foster complementarities (more market oriented) and others as aiming to foster similarities (more oriented towards technological innovation). This was presented during the "Club's Day" event by members of KMP's steering committee and solved many problems of roles and legitimacy of clubs and associations in Sophia Antipolis. Hence, the diffusion of KMP concepts beyond the telecom cluster shows the important needs in terms of representation and of development of exchange and combinative capabilities.

c) Public research labs stress their difficulty to adopt-adapt both the competency model and the cluster model.

6. **The change process:** at the end of this year, TV decided to pursue the project and to become project leader. The research teams still participate tthe project in order to follow the industrialization and more precisely to foster the emergence of a new compromise on both the competency and the cluster model.

Loop 4 (2005)

This last loop corresponds to the pre-industrialization of the project and results in the design of prototype 3. During this phase, we improve and simplify the three uses scenarios.

1. The feeling of discomfort: we conduct a new life-cycle in order to solve the public research labs problem of appropriation and to facilitate the pre-industrial phase. The public research labs problem is linked on the one hand to the difficulty to identify a business activity for describing their competencies; as a research laboratory director says: "we work on a very high and abstract level so that we don't wonder about such problems"; on the other hand, it is due to their lack of visibility in the cluster model 1. Concerning the industrial phase, the main problem is to facilitate the implementation of the KMP solution in other clusters.

2. **Building a theoretical support:** here, we aim to better understand the link between similarity and complementarity of competencies and the exchange and combinative capabilities inside a cluster. According to Kogut (2000: 407) *"Networks offer the benefit of both specialization and variety* generation*. The superior abilities of markets to generate variety is a commonplace belief… The converse of this statement is that firms are superior vehicles for the accumulation of specialized learning… Specialization and variety are antithetical within the firm, but define complements within a network".* Thus, networks or clusters offer an interesting heterogeneity of available knowledge for exchange and combination among firms. Also called knowledge based coherence, knowledge interesting heterogeneity may be defined as the potential of synergies and new combinations from a diversity of knowledge and competencies (Christensen and Foss 1997; Barlatier 2006). Similarity and complementarity therefore provide a better understanding of the concept of coherence or interesting heterogeneity.

This theoretical framework leads to build new rules for designing a cluster. We maintain the three main categories of actors: facilitators (relational competencies), stakeholders (firms and public research labs who possess technical competencies), consultants (managerial competencies). Each stakeholder is positioned depending on the concept of similarity, which provides views of technological poles. One or more value chains cross these technological sectors. In this case, value chains are not predefined but designed from data storage in the ICT solution. In this perspective, value chains are potential and flexible. They are resulting from queries and are composed of competencies sharing the same business activities. Finally, we improve the competency model by dividing the item 'business activity' in three sub-items: generic uses, business sectors, and markets.

3. Uses scenarios: because there are not new uses scenarios, the contextualization of the design rules was realized from interviews of evaluation conducted during the previous loop. These interviews had for example allowed to define generic uses in the specific case of a telecom cluster, such as mobility, security, traceability …

4. Building archetypes: prototype 3 includes a new representation of the common space (the cluster model 2 –see figure 4-), new interfaces providing clustering views (as technological poles or value chains) and new ontologies of competencies.

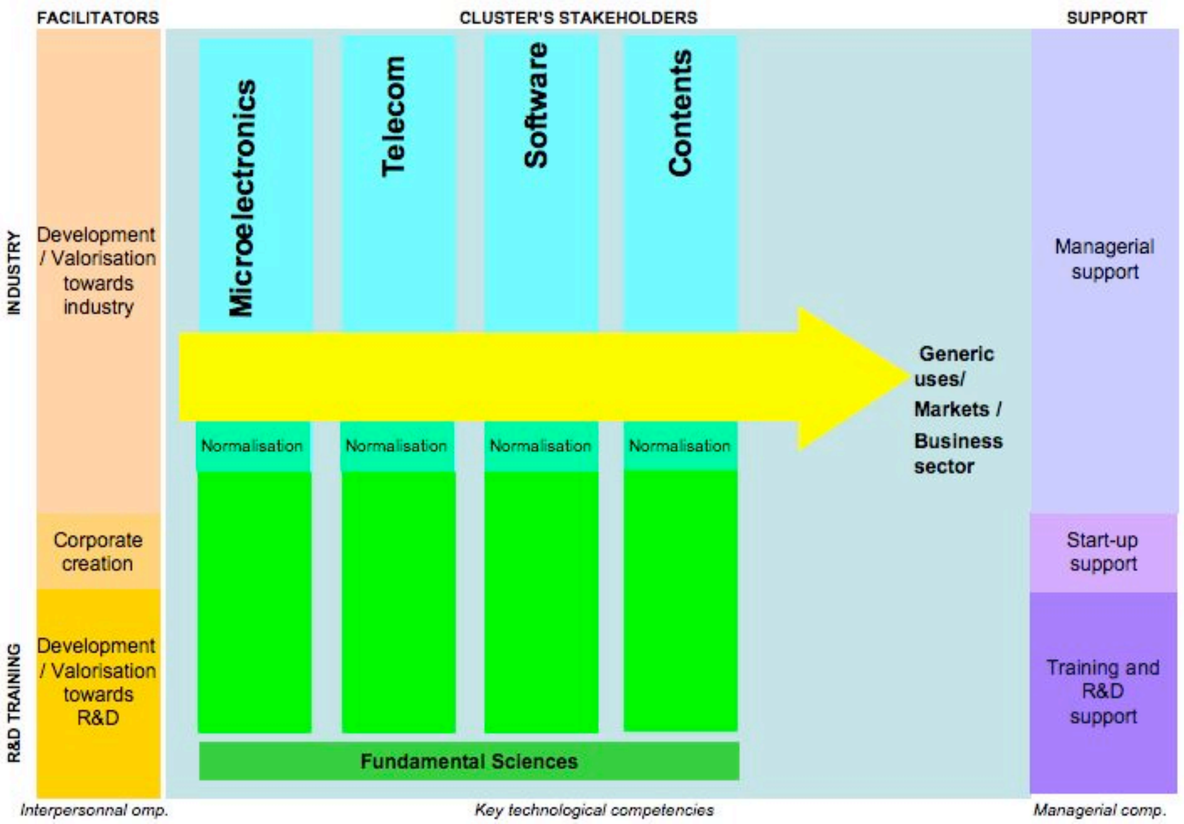

Figure 4: the cluster model 2

5. Experimentation: the new model of cluster, based on the "similarity / complementarity" concepts, was adopted and reused by the PACA region in order to present a national project on competitiveness poles, the "SCS" pole (Secured Communicating Solutions). These concepts have a huge impact by structuring the presentation of cooperation projects within the pole, showing then their impact on clusters' combinative capabilities and anticipation of created value. This represents an important enlargement of the socio-technical network, which now integrates actors located in all the PACA region, not only in the technopole of Sophia Antipolis. Thanks to this growing interest of actors, two public financiers in charge of territorial development decided to support the industrialization of the KMP project. At the end of this loop, 412 competencies were registered by 63 firms and 4 public research labs.

6. **The change process:** the change process will be analyzed when the KMP solution, in its industrial version, will be implemented in the telecom cluster. A first version of the KMP solution will be online in July 2007.

3. Results and Discussion

The previous section detailed each step of the methodology used and showed the progressive building of the KMP solution. We would like now to discuss the role of boundary objects in the KMP experimentation. First, we will focus on the emergence of compromises between designers and users. Secondly, we will emphasize the role of boundary object in the emergence of a collective learning process. Finally, we will stress the key characteristics of boundary objects.

3.1. Boundary objects: support of socio-technical compromises

As we shown above, intermediary productions have been built at each loop. These intermediary productions result from interactions between both designers' world and users' world. In other words, these intermediary productions result from interactions between designers' hypothesis translated in design rules and users' practices. As such, they represent socio-technical compromises in their concrete form.

These interactions are summarized in the figure 5 where for each loop, we first identify the main design rules (designers' world). Then, we notice the main actors who constitute the socio-technical network i.e. who participate to the adoption-adaptation process (users' world). Finally, we describe the intermediary productions built in each loop, which represent the project evolution.

	2001/2001 Loop 1	2003 Loop 2	2004 Loop 3	2005/2006 Loop 4
Designers' world	R $_{1.1.}$: to identify the competencies' s capital R $_{2.1.}$: to foster social and cognitive proximities	R $_{1.2.}$: to build a competencies map based on the competency model R 2.2.: to build a share common space based on the TV' value chain.	R 1.3.: to analyze the actors' interest to cooperate by evaluating their similarity / complementary competencies R 2.3.: to enrich the common space representation by integrating all the cluster actors (cluster model 1)	R 1.4.: to enrich the competency model by dividing the 'business activity' item in three sub items R 2.4.: to simplify the common space representation in order to facilitate its replication (cluster model 2) R 3.4.: to analyse the cluster capital of competencies by identifying technological poles and value chains
Project	KMP project - RNRT	P1 - Competencies cartography - Competencies ontologies - TV value chain	P2=P1+ - Queries on partner looking for - New representation of the common space - Clustering views to analyze the cluster	P3=P2+ - New competencies ontologies - New common space representation - New clustering views to evaluate the capital of competencies
Users' world	- Two TV commissions - TV supports the project during its steering committee	- New pilots arrived thanks to an increasing interessement on the competencies description modalities. - Value chain appropriation by all the TV firms	- Pilots want to industrialize the KMP solution - Sophia Antipolis' clubs and association interest in the solution - Lack of appropriation of the competencies description modalities by public researchers	- New public financers - TV becomes the project leader and is in charge of its industrialization - KMP concepts are used to structure the SCS pole

Figure 5: emergence and development of socio-technical compromise

This figure shows that both design rules concerning the competencies map ($R_{1.n.}$) and the share common space representation ($R_{2.n.}$) implemented in the successive prototypes 1, 2 and 3 have constituted strong boundary objects allowing both the emergence of exchanges between designers and users and then the stabilization of socio-technical compromises.

Let us illustrate the above with the example of the common space representation.

In the Sophipolitan 'Telecom' Cluster, firms are evolving in a multi-technological context covering a wide range of industries from computing and multimedia to space, information processing, on-line services and networking, and microelectronics. This multi-technological environment is the source of an identity problem. We decided to build a share common space representation in order to solve this problem and to foster social and cognitive proximities. As a cluster often includes different values chains (Nooteboom and Woolthuis 2003), we decided, in collaboration with local actors, to represent the main global value chain representative of the telecom Sophipolitan cluster (common space representation n°1).

Based on the MIT mobile phone and internet value chains, and after an adaptation-adoption process with local actors, a compromise on the TV value chain emerged and has been stabilized for two years (2003-2004). By the end of 2003, during the annual general meeting of TV, all the firms were asked to position themselves on the value chain (cf. loop 2). This outlines the growing interest of actors in scenario 2, 'to explore TV'. However, this value chain did not represent all the TV members. Indeed, research laboratories, facilitators and supporting functions were not represented. Thus, during the following loop, a new common space representation (n°2) was built in order to integrate all actors. It tries to represent a cluster in its whole (see the cluster model 1, fig. 3, loop 4). The discussion on scenario 2 led the designers' team to complement the map of competencies with an analysis of the actors' interest to cooperate. In this line of thought, we suggest the concept of similarity/complementarity based on the seminal works of Richardson (1972). Exchanges around these concepts resulted on two main effects: first, we built new interfaces that propose clustering views of technological poles or value chains (see loop 4). Secondly, in cooperation with all sophipolitan clubs and associations, we built a clubs map in order to identify better their role and their complementarity within the sophipolitan territory (see loop 4). However, during this loop, research laboratories expressed some problems concerning the common space representation (n°2) due to their lack of visibility. At the same time, the willingness of the TV members to industrialize the solution argued in favor of a more standardized cluster representation. Based on the concepts of similarity/complementarity appropriated in the previous step, a new representation was built (cluster model 2, fig. 4, loop 4). Nowadays, this representation is still valid. The SCS pole is currently using it. At the same time, the clustering view of technological poles and value chains was enriched by adding new calculations on actors, competencies and existing cooperation. These new calculations enrich analysis on the competencies capital of a cluster developed in the next section.

In conclusion these successive compromises gave a strong orientation of the project in favor of scenario 2, which was progressively enriched. Indeed, the scenario 2 rapidly evolved from the generic use ‘to explore TV’ to the generic one ‘to manage a cluster’.

3.2. Boundary objects: support of a collective learning process

As shown in figure 5, boundary objects are based on rules identified by designers. In this perspective, they afford a working hypothesis (Béguin 2003). Indeed, according to Béguin, utilization of these artifacts in the users’ activity constitutes an opportunity for testing the hypothesis of designers, revealing their consequences and possibly enriching or shifting them. In this perspective, these objects incorporate the knowledge coproduced during the design process; uses in real practices improve the validity of this produced knowledge.

In the KMP project, the mutual learning process has been developed around two main models, both the competencies and cluster model, implemented in the successive prototypes. This process has produced both theoretical and actionable knowledge.

3.2.1. The competencies model

By articulating two fields of competencies literature (strategic and human resources), we proposed a new abstract representation of competencies. This abstract model allows to identify resources, which represent different pieces of knowledge’s combined in the same competency (systemic principle), the action realized (actionable principle), the result of this action (visibility principle) and the business activity in which this competency participates to create value (finality principle) (Rouby and Thomas 2004). This abstract model, complemented with ontologies, permitted to locate competencies and to compare them depending on the interest and vision of actor, who could choose the appropriate level and combination of items relevant for him.

In the diverse prototypes, many interfaces are based on the competency model. These interfaces allow to describe actors’ competencies and to look for a partner. They produce actionable knowledge in three domains:

- To identify its own competencies: *"the KMP solution provides a better understanding of itself, a better awareness of its firm's competency wealth"* (managers of different MNC);
- To influence its communication strategy notably in the case of SME;
- To provide rules to look for a partner: simplified and complex queries (see loop 4).

In this case, uses in real practices were crucial. For example, in the KMP project, the concrete and real description of competencies increased the trust in the competency model (very accurate without revealing strategic know-how); it has proven its usefulness to look for a partner and it has finally led to non-anticipated uses (awareness on its own competencies) or to emergent uses (calculation of similarity and complementarity).

3.2.2. The cluster model

Both Knowledge Based View and cooperation theory allowed to build design rules concerning a cluster representation. This representation serves as a basis to codesign the TV cluster representation. The process of adoption-adaptation during three loops enriches the design rules and provides at last loop a generic cluster model. On one hand, this model provides an abstract representation of a cluster common space essential to reinforce the feeling of identity. On the other hand, it allows a first analysis of the cluster's capital of knowledge:

- The number of technological poles indicates the variety of knowledge capital. The number of competencies and of actors present in each pole is indicated by percent; this shows the distribution of competencies across the technological poles inside a cluster.

- The number and the weight (number of competencies and actors in percent) of the main value chain indicate the potential synergies among heterogeneous knowledge inside a cluster. Indeed, as the degree of concentration in an industry can be measured, the degree of coherence in a cluster can also be measured. For example, C_5 indicates the percent of competencies inside the five main value chains of the cluster; if $C_5 > 80$ %, the coherence of the cluster's capital of knowledge can be considered as strong. Conversely, if $C_5 < 50$ %, the coherence has to be reinforced.

The building of an ICT solution needs to precisely define the concepts and to be as coherent as possible in the way they are combined. These constraints reinforce the production of theoretical knowledge. In our example, the fine definition of similarity and complementarity allow to enrich the concept of interesting knowledge i.e. the 'coherence' of a cluster (see loop 4).

The cluster model interfaces built in all successive prototypes allow for the creation of actionable knowledge in three domains. First, these interfaces allow to realize a diagnostic of current situation concerning the knowledge base of the cluster and the interactions of different components of knowledge. Many practitioners stress the necessity to identify mass effects, lacks and / or complementary effects.

Secondly, this diagnostic enables to create individual and collective vision of strategic development. The cluster representations enhance actors' capabilities to anticipate the created value through partnerships as they are able to select the best cooperation opportunities and perspectives (individual development). As a practitioner of the microelectronics domain says, the cluster model provides "*a better understanding of the reason why actors work together*". These representations have also effects on access to exchange and combination, because identified needs within the network is, for instance, a source of attraction of newcomers.

Finally, this collective vision creates emergent rules of managing the cluster. On the one hand, this vision creates rules concerning newcomers: only actors who are able to position in the common space can integrate the TV association. On the other hand, this vision creates rules concerning the governance of a cluster: only stakeholders of the cluster have the possibility to access to the executive board of the cluster. Recently, an executive member of the board tells us the following example: the incubator director asked to access to the TV board. This access was refused notably because incubators were supporting functions and not stakeholders (see fig. 4). This executive board member stresses the fact that *"today, TV is a rational association; the KMP project structured the association"*.

The KMP experimentation underlines the role of boundary objects in the creation of both theoretical and actionable knowledge. This project also emphasizes that the production of these two kinds of knowledge is linked and that they influence each other (Pascal and Thomas, 2007).

3.3. Key characteristics of boundary objects

As intermediary productions, boundary objects play a critical role in the emergence of both socio-technical compromises and mutual learning processes. In order to play this role, three key characteristics seem to be essential:

- ***Robustness***

As described above, boundary objects incorporate all the knowledge (TK and AK) produced during the design process and allow their interactions. At the beginning of the KMP project, these objects served as mediators between actors: they incorporated a low level of knowledge and essentially a theoretical one. Progressively, the level of both theoretical and actionable knowledge incorporated in boundary objects increased, reducing at the same time the different trajectories of the project development. Boundary objects are more and more robust by incorporating knowledge that is more and more generic. This generic characteristic of knowledge increases the ability to use the solution in different contexts and to produce, in each specific context, new actionable knowledge. Here, boundary objects allow to support a generative dance between knowledge and knowing (Cook and Brown, 2002).

- ***Openness***

The use of flexible, plastic, reconfigurable objects allows each world to adapt them to its purposes and needs. In the KMP project, the use of a semantic web service based on ontologies provided a wide flexibility in the competencies description.

- ***Simulation/ visualization capacity***

It is interesting to use computing models as boundary objects. Indeed, as such, they offer immediate representations of the analyzed situation (Chanal *and al.*, 1997). For example, representations of pole or value chain to evaluate the coherence of the knowledge base. These visual representations are a basis for practitioners - designers' communications and enrich the knowledge creation process.

The evolution of the common space provides an illustrative example of these three characteristics. The first representation is the main TV value chain. This value chain is highly contextual and specific to the TV case (few open and few of theoretical knowledge incorporated). However, this concrete representation enables a communication process to emerge rapidly (visualization capacity). As such, this representation cannot be used in other clusters. Conversely, the last common space representation (see fig. 4) is based on very generic knowledge (concept of similarity and complementarity) which increase its robustness. Moreover, thus representation is based on a highly open model and can be re-used in all clusters by adapting it.

Conclusion

The objective of this paper was to propose a use oriented methodology for designing an ICT solution. Our methodology provides new insight into how achieving appropriation of ICT tools in organizational contexts. This methodology is based on three main characteristics.

- The dissociation of the designers' world from the users' one in order to understand better the emergence of uses in real work practices; the utilization of artefacts in the users' activities constitutes an opportunity for testing, enriching or shifting them.
- An iterative cycle process: building intermediary productions at each loop allows to articulate the multiple rationalities existing in a network. This articulation or reconciliation requires substantial labor of translation, negotiation, debate, triangulation and simplification. This labor, also called process of *interessement* (Akrich *and al.* 2002), enables the enlargement of the socio-technical network.
- A specific role of boundary objects: they foster the emergence of socio-technical compromises and mutual learning processes. As such, boundary objects play a critical role in the coevolution of both designers' world and users' world.

Finally, we want to underline that design is a typical mode of research that produces knowledge at the service of action (David, 2000, Romme, 2003, Van Aken, 2005). Our design methodology argues that the construction of successive boundary objects and their uses in real situations allows close interactions between scholars and practitioners, an emergent process of arbitrage in which researchers and practitioners engage with one another to produce together the solutions and, also, both theoretical and practical knowledge in the field of management. Moreover, this use oriented design methodology proved its efficiency in the specific case of a multi-actor environment.

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