A design theory for collaborative interorganizational knowledge management systems

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ABSTRACT

This paper addresses the design problem of providing IT support to organizational knowledge creation within a geographical cluster. This study is based on a design science approach that serves to successfully introduce and implement a new IT artefact as a tool for interorganizational knowledge management. We draw on a case study of developing a portal for mapping competencies in an IT cluster in France. Abstracting from the experience of building this system, we developed an IS design theory for collaborative interorganizational knowledge management systems.

Key words

design science, design theory, knowledge management, cluster, interorganizational system

Introduction

Organizational knowledge creation is above all a social process (Gupta et al., 2009; Kogut and Zander, 1992; Nahapiet and Ghoshal, 1998; Shawney and Prandelli, 2000). In this respect, Moran and Ghoshal (1996) and Nahapiet and Ghoshal (1998) argue that, from a Schumpeterian perspective, organizational knowledge creation is based on two key mechanisms: exchange and combination. Creating new knowledge therefore requires combining elements previously unconnected or developing novel ways of combining elements previously associated (Nahapiet and Ghoshal, 1998). When resources are held by various agents, exchange is a prerequisite for resource combination.

The study of these social knowledge-creation mechanisms emphasizes the necessity for organisations to open themselves to the outside in order to gain new knowledge (Van de Ven, 2005). As such, the networks these organizations are part of represent a privileged source of knowledge acquisition, and provide structures and stability that can be used for collective learning (Håkansson, 1993; Kogut, 2000). Hence, these networks appear to operate as organizational configurations able to create, accumulate and transfer collective knowledge (Foss, 1999; Kogut, 2000). Moreover, 'network capabilities' can emerge from the interactions of the actors within the networks (Foss, 1999; Kogut, 2000). The literature reveals two main aspects of network capabilities: their architecture and identity (Kogut, 2000). Network architecture refers to the links structure, the types of actors and the coordination mechanisms, while network identity refers to shared goals, beliefs and behaviours. Romanelli and Khessina (2005) define a cluster identity as, first, the shared understanding regarding the kind of businesses that already exist and thrive in the cluster, and second, as the basis for signalling and discussing the relative suitability of this cluster for particular kinds of business activities.

Network architecture and identity are rarely formed by design, but rather “arise from inherent characteristics of technologies that populate an industry, as well as social norms and institutional factors that favour the operation of particular rules” (Kogut, 2000: 410). Thus, the question how the development of an effective network identity and architecture can be facilitated in order to foster innovation through knowledge exchange and combination remains unanswered and constitutes a major challenge – especially for a variety of geographical clusters of firms and other organizations that have emerged in the last few decades in all parts of the worlds.

This paper addresses the design problem of providing IT support to organizational knowledge creation within a geographical cluster. Designing and creating an IT artifact in this context is innovative in two ways. First, existing theories (e.g. Doherty and Terry, 2009) may not be applicable to the managerial problem of fostering innovation within a cluster. Second, this innovative artifact requires specific design efforts dedicated to a multi-actor environment. Hence, in this study we adopt a design science research approach. According to Hevner (2007), design science research is motivated by the desire to improve the environment by introducing new and innovative artefacts and the processes necessary for building them. Moreover, design science research serves to develop a general solution applicable to a class of problems (Markus et al., 2002).

This article draws on a specific design research project, the Knowledge Management Platform project (KMP project). The goal of this project was to build a semantic web service of competencies in order to foster innovation within the Telecom cluster of Sophia Antipolis (Alpes-Maritimes, France), using an interactive map of competencies.

This paper is organized as follows. First, the question of how to design an interorganizational knowledge management system is explored. Then, we describe the specific methodology used to design this system. Subsequently, we describe the KMP experience which consists in designing a portal for mapping competencies in a cluster. Finally, we discuss the findings from this case study and more particularly outlines a design theory for a collaborative interorganizational system.

1. Questioning the design of a collaborative interorganizational knowledge management system

After a brief review of the design science research literature, this section will outline and discuss the class of problems to be resolved.

1.1. Information systems and design science research

Recently, there has been a rise in interest in design science research. This is has become evident through the appearance of recent publications in, for example, *MIS Quarterly* (Hevner et al. 2004; Markus et al. 2002), a number of articles in a recent special issue of *Journal of Information Technology Theory and Applications* (Walls et al., 2004; Goldkuhl, 2004; Hooker, 2004) and *European Journal of Information Systems* (Baskerville, 2008; Winter, 2008). According to Baskerville (2008), the aim of design science is to systematically create knowledge about, and with, design. As such, "design science is directed towards understanding and improving the search among potential components in order to construct an artefact that is intended to solve a problem" (Baskerville 2008: 441). In their seminal work, Walls et al. (1992) argue that a prescriptive Information System Design Theory (ISDT) should aim at enabling designers to construct "more effective information systems" (Walls et al., 1992: 36). Moreover, because design is both a noun and a verb, any design theory has to deal with both a product and a process. An ISDT therefore refers to an integrated prescription consisting of a particular class of user requirements, a type of system solution with a set of system features, and a design methodology to guide the process of development (Walls et al., 1992).

Thus, design science approaches in the IS field share an interest in developing prescriptive knowledge to foster relevance for practitioners. Here, design processes and products are two sides of the same coin. Indeed, the design process involves iterative build-and-evaluate loops (Hevner et al., 2004) that provide information feedback to improve both the quality of the product and the design process. These two design activities rely on existing "kernel theories" and, in this sense, design embodies the principles of these theories (Walls et al., 1992). Thus, the design process starts with deriving requirements from kernel theories and defining (preliminary) hypothesized design and development principles that meet these requirements. These hypothesized principles serve to specify system features.

1.2. The class of IS problems: a collaborative interorganizational system supporting knowledge creation in a geographical cluster

The question regarding how to develop an inter-organizational system supporting knowledge creation in a geographical network has received little attention in the IS literature. In fact, no existing system supports all the requirements related to this class of problems. First, the question of how to foster innovation in a geographical cluster is not resolved in the management literature (e.g. Löfsten and Lindelöf, 2002; Iansiti and Levien, 2004). As we saw previously, previous research on knowledge creation and innovation in clusters provides some insights, but has not dealt with building network architecture and identity.

Second, the design process in this study takes place in a multi-actor environment. Here, Volkoff et al. (1999) raised the problem of designing and building a collaborative interorganizational system (IOS) to support a symbiotic management network, pointing at the problem of a lack of leadership and administrative hierarchy in such a network.

Finally, the process being studied can be defined as an emergent knowledge process, characterized by three main features: "an emergent process of deliberations with no best structure or sequence; requirements for knowledge that are complex (both general and situational), distributed across people, and evolving dynamically; and an actor set that is unpredictable in terms of job roles or prior knowledge" (Markus et al., 2002, p. 179).

Indeed, the development of an IT artefact supporting emergent knowledge processes requires an emergent and iterative development methodology: "design for customer engagement by seeking out naïve users; design for knowledge translation through radical iteration with functional prototypes; design for offline action; integrate expert knowledge with local knowledge sharing; design for implicit guidance through a dialectical development process" (Markus et al., 2002, p. 206). Indeed, the use of pilot implementation is essential in the development of a knowledge management system (Butler et al., 2008).

2. Method

This section describes the KMP experience which was conducted in the well-known technology park of Sophia Antipolis (SA) in France (Castells and Hall, 1994). For this project, we relied a new process for developing the system called the integrative design science methodology (Pascal et al, 2013). The development principles guiding this methodology are described thereafter. These principles are part of the design theory. Their application in the KMP experience reveals some unintended findings discussed in the reminder of the paper.

2.1. The Knowledge Management Platform case

Since the mid 1990s, the SA cluster has progressively developed from a computer industry to a telecom and IT industry cluster (Krafft, 2004). As such, Telecom Valley, a non-profit organization, was founded in 1991 by eight leading firms and other organizations in order to facilitate collaboration.

In 2000, the main characteristics of the Telecom Valley (TV) cluster could be summarized as follows (Lazaric et al, 2008). First, firms in this cluster were evolving in a diverse technological context, covering a wide range of industries (e.g. computing, multimedia, space, information processing, on-line services and networking, and microelectronics). Given that most parent companies were located elsewhere, the participants in the cluster had been developing strong external links. The internal dynamics of the cluster arose from the interactions in several communities, associations, clubs, and so forth, but also revealed a huge potential synergy between agents in the cluster that was still largely unexploited.

The lack of internal dynamics was the starting point of the KMP project, launched in 2001 by TV. Because they only have a partial view of the different flows of knowledge developed by the actors of the cluster, members of TV asked a map of competencies to create strong local links with local high-tech SMEs and research institutes. The objective of the KMP project was thus to build an interactive map of competencies which suggests a lack of shared representation of who knows what within the cluster.

2.2. An integrative design science methodology

To address the research objectives, we define an integrative design science methodology that connects two perspectives on design: *science-based design* drawing on design propositions grounded in research and *human-centred design* emphasizing an active and systematic participation by users and other stakeholders (for more details on the methodology see Pascal et al, 2013). This methodology and its inherent development principles are relevant in the case of designing an innovative solution, where there generally is no or limited scientific and practical knowledge that is closely tied to the design goals at hand (Pascal et al, 2013). It is also pertinent because it assumes that technology per se cannot determine work practices and thus incorporates an enlarging network of users at different stages of the design project (Newell et al, 2009; Nevo and Wand, 2005).

This methodology involves six steps (see Figure 1). These steps typically need to be taken in many iterations, acknowledging that each step overlaps and is highly intertwined with other steps.

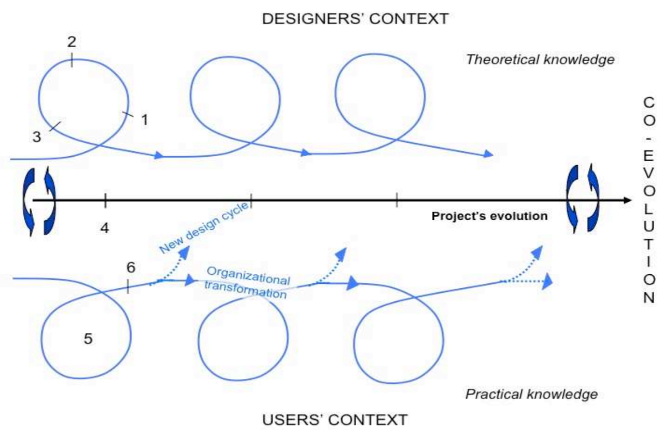

Figure 1. Towards an integrated design science methodology

1. Problem awareness. Before one can identify any knowledge relevant to address a particular design challenge or assignment, a clear understanding of the nature of this assignment is needed. In this paper, the practical problem is to foster knowledge creation in a geographical cluster (see next section for more details).

2. Developing design propositions. The scientific knowledge relevant to the key problem addressed is identified and synthesized into design propositions thanks to the CIMO logic. CIMO involves four components: (1) a problematic *Context*, in terms of the surrounding (external and internal environment) factors and the nature of the human actors influencing behavioural change, (2) which suggests a certain *Intervention* type that managers have at their disposal to influence behaviour, (3) to produce, by way of particular generative *Mechanisms*, the processes that in a certain context generate (4) the intended *Outcomes* (Denyer et al, 2008).

3. Creating scenarios of use. Scenarios of use serve to explore the organizational context where work practices are meaningfully accomplished (Pascal and Rouby, 2006) and serve to convert and articulate tacit knowledge of practitioners, and as such, provide input for enriching the design propositions (Plsek et al, 2007).

4. Designing and developing artefacts. Drawing on input from the (initial set of) scenarios of use and design propositions, design work on artefacts is conducted. Artefacts are the tangible result from the design process and arise from contextualizing and applying design propositions to particular practices.

5. Experimenting with prototypes. For any information technology (IT) artefact, the design evaluation process can not be limited to IT performance but has to involve an in-depth study of the (intended) artefact in its business environment (Hevner et al, 2004; Pandza and Thorpe, 2010). As such, the experimentation process exploits the potential role of prototypes, extending the similar role of other artefacts (e.g. drawings) developed and used in earlier stages of the design process.

6. Organizational transformation. Finally, the collaborative learning process may progressively change the organizational context (or fail to do so). As a result, the initial managerial problem typically evolves, leading to redesign efforts or an entirely new design cycle.

2.3. Main Actors and Interactions

Researchers from different academic fields composed the project team: economics and management, computer science and ergonomics, telecommunication sciences. The number of users engaged in the project has gradually grown from two TV working groups and several pilot users to representatives of all TV' actors. At the end of the project, all other TV members, several clubs and associations in the SA territory, and IT firms located outside SA participated in the project but without a direct involvement as pilot users.

Interactions between designers and users occurred through three different modes: interviews (26 open interviews with key stakeholders, 52 semi-structured interviews with pilot users, and 21 interviews with users as well as other stakeholders to evaluate the prototypes), regular meetings (like steering committee composed of users and members of the project team) and occasional meetings (like progress reports to diverse entities). Overall, we employed a purposeful sampling strategy (Kumar et al, 1993) towards all key stakeholders of the KMP project.

3. Results

This section explores the development of the KMP solution according to the six steps methodology. As such, it outlines the two types of design principles which are inextricably intertwined: principles governing the development or selection of system features and principles guiding the development process.

3.1. Preliminary work - design cycle 1

The first project cycle involved analyzing the context so as to understand the practical and research challenges and to define the goals of the project. As observed earlier, in 2001 there was a lack of local links and synergies between the members of TV - due to its history of focusing on external growth - and the broad scope of technologies within TV. These two characteristics not only led to a heterogeneous and disconnected body of knowledge, but also to an underdeveloped cluster identity and a lack of mutual understanding.

These issues raised a theoretical question with regard to the dynamics of knowledge creation within a cluster, and this question prompted the design team to study the literature on knowledge management, or more precisely knowledge creation. Based on previous work by Moran and Ghoshal (1996), Nahapiet and Ghoshal (1998) identified four conditions that would render exchange and combination as knowledge creation mechanisms effective:

1. The first condition is that the opportunity to engage in exchange and / or combination of knowledge exists.
2. The second condition is the capability to anticipate combination possibilities and the different ways to exploit them.
3. The third condition is that participants are motivated to engage in exchanging and combining knowledge.
4. The fourth proposed condition is the capability to combine knowledge.

Indeed, the aim of the project was to foster knowledge creation by increasing the exchange and combination of knowledge between the different actors of the cluster, such as firms and public research laboratories. In this respect, practitioners in TV typically tried to identify and find (potential) partners on the basis of their competencies. As such, they tended to speak about 'competency mapping' rather than knowledge mapping. Once the searched-for competence was identified in a partner, an effective partnership would facilitate the exchanges and combinations of specific knowledge elements embedded in the different partners' competencies.

Based on these insights, we produced the following meta-design proposition:

> In a multi-actor cluster with a broad scope of technologies (*context*), an interactive map of competencies (*intervention*) will serve to foster knowledge creation (*intended outcome*) by reinforcing the four conditions for exchanging and combining knowledge: opportunity, anticipation, motivation, and combinatory capability (*generative mechanism*).

This set of conditions refers to the generative mechanisms for fostering knowledge creation within a cluster (Nahapiet and Ghoshal, 1998). The meta-proposition thus identifies a potential link between a specific intervention in a specific context, such as the interactive mapping of competencies, and the generative mechanisms of knowledge creation, which in turn are likely to produce a particular outcome, such as knowledge creation. However, this proposition does not specify the intervention modalities in terms of what kind of solution is needed and how to develop it. Here, the precise and iterative analysis of the interactions between an intervention and generative mechanisms may create both theoretical and practical knowledge regarding the dynamics of knowledge creation within a cluster.

On the basis of this meta-design proposition, therefore, subsequent steps involved drawing up more precise design propositions with regard to the (intended) technical and organizational solutions that would serve to foster the dynamics of knowledge creation within the cluster. Developing these design propositions implied the need for a deeper understanding of the generative mechanisms. In turn, the implementation and testing of the solution in real-user cases would enrich the knowledge of generative mechanisms on the dynamics of knowledge creation within a cluster.

During this first cycle, both the positive evaluation by the French Telecom programme 'Réseau National de Recherche en Télécommunications' (RNRT) and the support gained from the annual general meeting of TV served to create interest and engagement.

3.2. Design cycle 2 (2003) - focus on the map of competencies

During the second design cycle, the design team developed the first prototype, which included a map of competencies, fostering the opportunity to exchange and combine knowledge. We choose to describe competencies instead of knowledge because competencies combine knowledge in action for the output at hand.

Problem awareness. The main challenge here was to describe competencies across a cluster of firms in sufficient detail, without disclosing strategic know-how. We responded to this challenge by both studying the literature and questioning several expert practitioners on their practices of finding a partner.

In the literature, we looked for a competency framework that would serve to describe the actors' competencies and provide the information needed by the practitioners. Because this framework did not exist in the literature, we developed a model that corresponded to it, incorporating the competence-based view and human resource management. More particularly, the following ideas were inferred from the literature. A competency involves four aspects: systemic composition, actionability, visibility, and finality (Rouby and Thomas, 2004). A competency therefore results from an individual or a collective action (actionability) that produces an output (visibility). Moreover, it is composed of a combination of resources and abilities (systemic composition) and results from a strategic intention (finality) in response to a market need. In other words, the map of competencies needs to incorporate action, resources, delivery and business activity as the four key dimensions of competency.

At the same time, practitioners were interviewed to identify and describe their practices in finding partners and identifying the types of information needed for this inquiry (scenarios of use). On the basis of these interviews, the design team identified a set of queries that a map of competencies needs to incorporate in order to respond to them: these involved simple queries on, for example, a particular technology, such as “which firms are working with J2ME?”, a delivery; “who has succesfully produced video games?” or a business activity; “which firms are working in the 3G mobile sector?” as well as more complex queries that combined several items such as technology and business activities. These scenarios also showed that the appropriate level for describing competencies within a cluster was a collective one; that is to say, team competencies, and therefore suggested that description had to be flexible.

Design proposition. In conclusion, by combining theoretical and practical knowledge we established the first design proposition (DP1). This design proposition focused on how to locate competencies (intervention), facilitating the search for partners; in other words, fostering opportunities to exchange and combine knowledge (i.e. generative mechanisms regarding the first conditions for knowledge creation):

> DP1: In a multi-actor cluster with a broad scope of technologies (C), an interactive map of competencies (I) provides relevant information that enhances *opportunities* (M) for finding the good partner for R&D collaboration (O). To trigger the opportunity mechanism, a competency is defined as an action that mobilizes technical, scientific and managerial resources (incl. knowledge) to produce deliverables that are likely to create value in a business activity.

Prototypes. Using a semantic web service provides more flexibility when describing competencies. A semantic web is based on an ontology, which defines the words that constitute the area in which knowledge will be represented by the diverse actors involved (Gandon, 2001). Based on the competency model, a specific (tree-like) ontology for each category, such as action, resources, deliverables, and business activity, was built. At its highest level, this ontology is an abstract form that becomes more concrete as one descends to a lower level.

Figure 2: Example of competency description

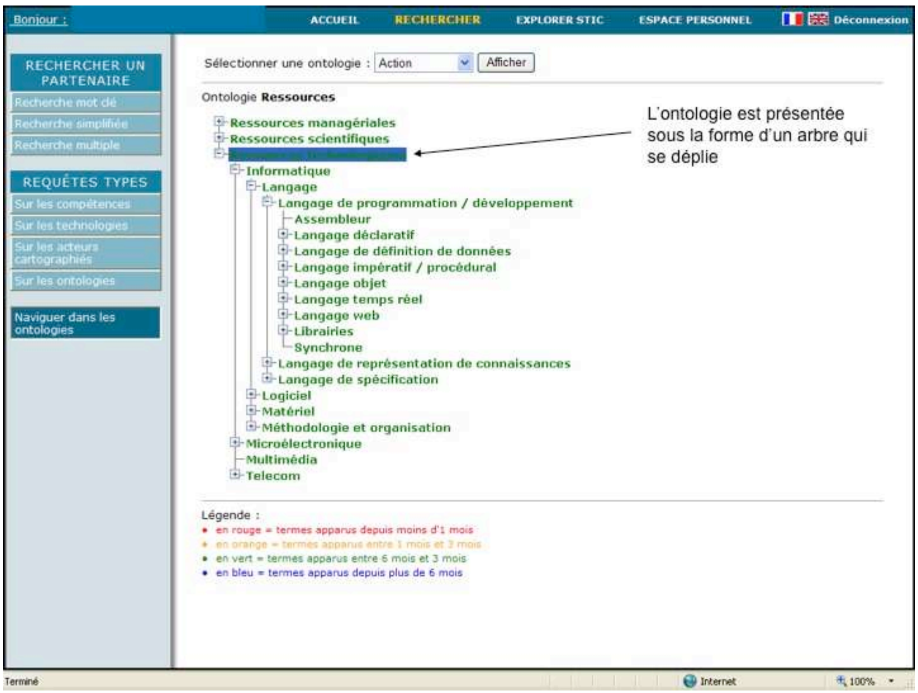

Figure 3: Example of ontology

Evaluation. A first prototype of the KMP solution was created and made available online to all firms in the TV cluster. This direct access to the prototype helped to sustain the initial commitment to the KMP project that participants in the cluster had developed at an earlier stage. In 2003, 73 competencies were fully described and registered by 9 pilot firms. These earlier real-use cases allowed practical knowledge to be developed in three different domains, supporting the effectiveness of the solution. First, the map created knowledge for participating firms regarding their own competencies. Second, it provided a better visibility of the cluster competencies which had an influence on the "communication and development strategies". Third, the map facilitated communication and enabled users to find partners more easily. In other words, this map enhances weak ties between cluster' members.

3.3. Design cycle 2 (2003) - the common space representation

The first prototype also included a common space representation that was improved during the subsequent cycles in 2004 and 2005-2006.

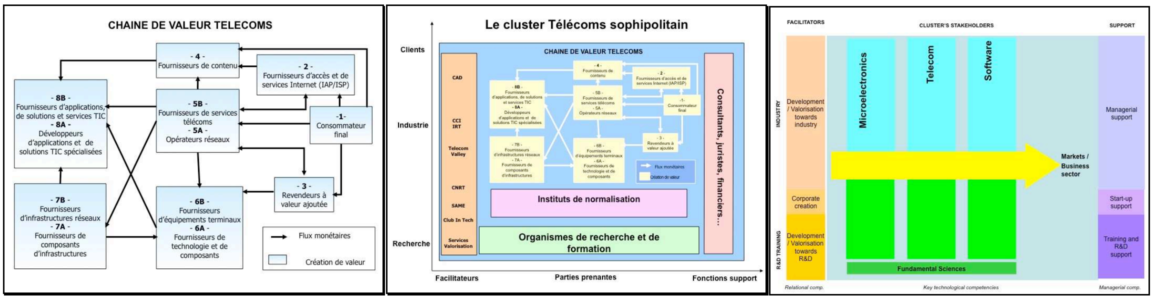

Figure 4: Improvement of the common space representation

Problem awareness. In this design cycle, a key issue in developing the portal for mapping competencies involved developing a shared identity of the cluster, as the members of the Sophipolitan telecom cluster did not have a clear idea of who they were.

The positive impact of a collective identity on motivation was underlined in the literature (e.g. Kogut, 2000). However, the literature provided no clues as to how this identity can be improved.

For members of TV's board, this lack of identity raised two problems (scenarios of use). First, it led to a problem of visibility: "there has always been ambiguity on whether Sophia Antipolis is more telecom or computer oriented." Second, it implied a problem of boundaries: "We never know when we have to accept the entry of a consultancy firm. Generally, the decision depends on the size of the firm. Thus, we lean more on political aspects than on industrial or innovation logics. We are not happy about this approach, but we don't know how to do it otherwise." Similarly, the president of TV observed a problem of geographical borders: “Do we have to accept a firm with a business activity that is in the core competency of TV, but which is situated kilometers away?”

Design proposition. These observations generated the idea that the representation of the cluster's common space can serve to improve the identity of the cluster; this led us to formulate the following design proposition:

> DP2: In a multi-actor cluster with a broad scope of technologies (C), building a common space representation of the cluster (I) reinforces the *motivation* of actors (M) to engage in R&D collaboration (O).

This representation was constructed by combining two distinct approaches. The first approach involved a strategic and economic analysis of the cluster, replying to the questions: ‘what is a cluster, and how can it be represented?’ The second approach focused on identity. Sammarra and Biggiero (2001) suggested identity is based on similarity and complementarity. Based on these insights and following the cluster definition proposed by Cook and Huggins (2003), we first represented the TV cluster in terms of its main value chain, focusing on the different firms that composed TV.

Prototype. This value chain representation needed to be instrumental in firstly, locating actors and competencies and secondly, detecting existing or potential interactions between actors in the value chain. Prototype 1 was finished and online by January 2004. Open access to the prototype for all members of TV resulted in an increasing real-world experiment.

Evaluation. Evaluations were conducted during 5 steering committees, which led to the validation of the prototype 1 composed by the map of competencies and the value chain as the common space representation. This first representation largely mobilized actors and consequently resulted in that, during the TV annual general meeting, all firms were asked to position themselves on the value chain. As a result, members of TV, and not only the pilot firms, adopted the proposed value chain, which extended the socio-technical network around the portal to all members of TV.

As such, this representation underlined competence complementarities as a key element of a cluster's constitution, although it did not clearly define its boundaries because only firms were represented. The impact of the value chain on the growing interest of TV members enabled us to improve this common space representation in the next loop.

3.4. Improvement of the common space representation - design cycle 3 (2004)

The common space representation was progressively constructed by successive iterations between theory and practice. In each loop, the cluster definition and its constitutive elements were improved. No new scenarios of use were built.

Problem analysis & scientific knowledge: A new representation was proposed. One of the objectives here was to represent all TV's members. According to the literature on regional studies (e.g. Keeble et al., 1998; Krafft, 2004), the main actors of a cluster are firms, public research laboratories, and organizations providing support. These actors are categorized in terms of their main competency: relational, managerial and/or technical (Arrègle et al., 1998; Dyer and Singh, 1998).

Design Proposition. DR2 was improved by a new representation which allowed three kinds of actors to be identified:

1. The stakeholders who participated in knowledge creation in the cluster; that is to say those who had technical competencies such as firms and public research laboratories.
2. The facilitators, including all associations, clubs or service providers, whose goal was to help find partners (relational competencies).
3. Support organizations in the area of law, finance and management that would ensure partnerships (managerial competencies).

Prototype. A new prototype was built, which included the new common space representation.

Evaluation: this was conducted during 4 steering committees and 12 interviews. These committees and interviews, complemented by the real-use experimentation, gave rise to different statements. The second representation improved the visibility of the cluster boundaries. However, it did not specify its constituting elements. Indeed, only one value chain was represented, whereas other complementarities were not yet visible. Moreover, the collective work on this second representation generated new needs and ideas to explore. For example, the President of TV suggested the representation could also serve to improve mutual understanding, in particular, to analyze the strengths and weaknesses of the cluster and to design a collective strategy for cluster promotion and development.

3.5. Improvement of the common space representation – design loop 4 (2005-2006)

Problem awareness & scientific knowledge: During the fourth cycle, we started developing the similarity and complementarity concepts (Richardson, 1972) to propose a new representation. Indeed, the evaluation of the degree of similarity and complementarity of the cluster's competencies capital served to highlight potential combinations that would possibly create value in the future. It allowed for a shared understanding about the relative suitability of clusters for particular kinds of business activity to be created (Kogut, 2000).

Design Propositions: The successive discussions and pilot-tests of the cluster representation served to improve the cluster representation in DP2 and to define a new design proposition. In this respect, a cluster representation (see DP2) that is instrumental in fostering identity and mutual understanding apparently combines two design parameters. Firstly, all actors are represented in terms of their main competencies; that is scientific and technical competencies (stakeholders), managerial competencies (support), and relational competencies (facilitators). Secondly, the competencies of stakeholders are positioned in technological poles (similarity concept) as well as value chains (complementarity concept). Thus, we defined the following design proposition:

> DP3: In a multi-actor cluster with a broad scope of technologies (C), an interactive map of competencies enabling users to evaluate the degree of similarity and complementarity of competencies (I) reinforces the *ability* of actors to *anticipate value* created from exchanging and combining knowledge (M), which in turn enhances the willingness to engage in R&D collaboration (O). To evaluate the degree of similarity and complementarity, the map of competencies draws on the following definitions: competences are similar when they share the same resources, and complementary when sharing the same business activity.

Prototype. The two design propositions DP2 and DP3 served to build an interactive representation of the TV cluster. In this last representation, value chains were not given, but dynamically built from the particular competencies described by the users in the platform.

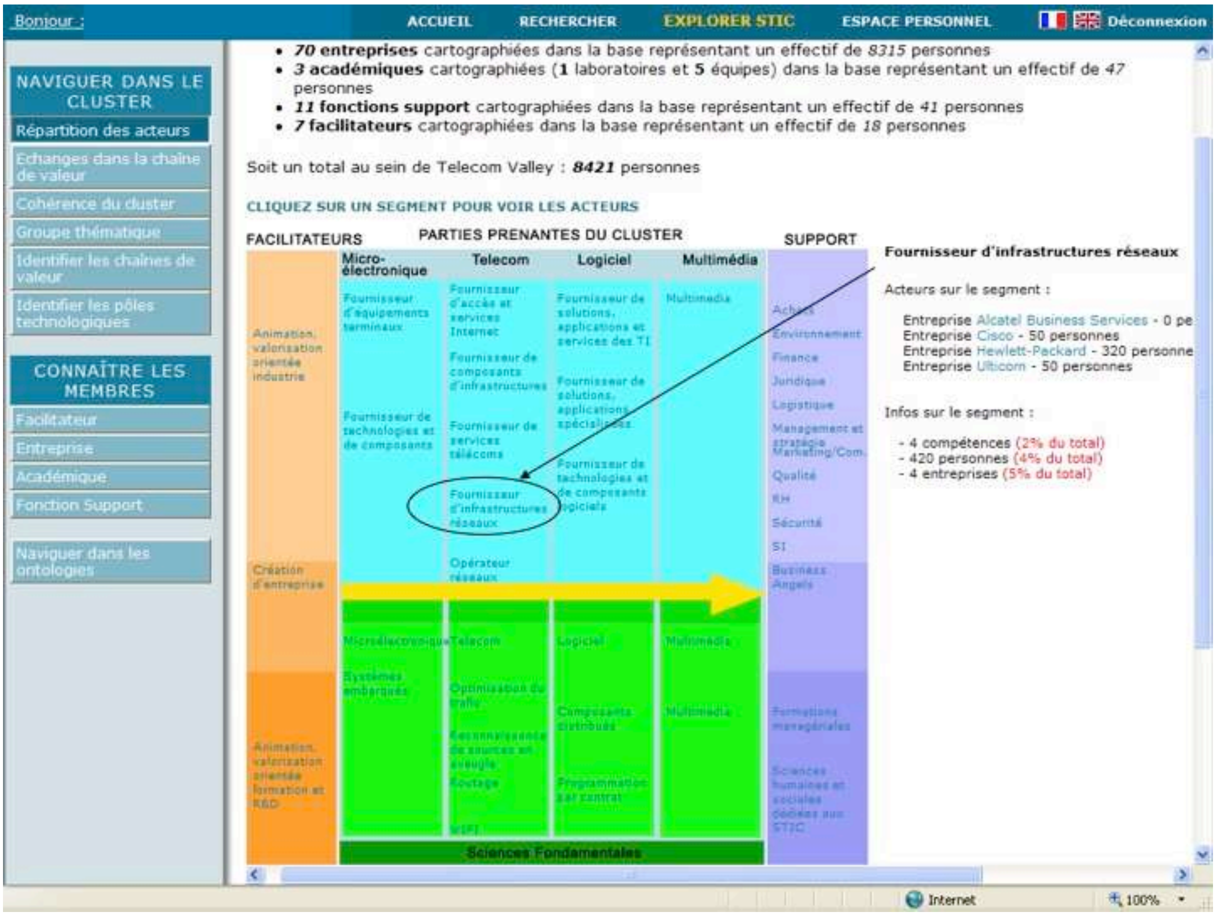

Figure 5: Screen shot of the prototype

Evaluation. This cluster representation was positively evaluated by all users during the steering committees. The work on similarity and complementarity concepts thus extended the socio-technical network from TV to other clubs and associations and finally to the SCS pole.

Here again, once implemented and available in the diverse prototypes of the KMP portal, its users produced practical knowledge. For example, the map of competencies related to the new common space representation allowed a diagnosis of the weaknesses and strengths of the cluster in terms of the nature and number of competencies in particular domains to be formulated. This resulted in a collective and shared understanding of the collective strategies of the cluster's development: fostering the entrance of new members where there were deficiencies, identifying newly emerging value chains to be reinforced in the future, and managing the boundaries. Based on these new understandings, TV's actors decided to accept new members from other close regions that potentially offered technical and scientific competencies mobilized in the different value chains of the cluster. They also decided to open the cluster boundaries by integrating multimedia firms because they would likely enhance certain value chains in the cluster.

On the whole, TV memberships evaluated the KMP solution positively as a tool to foster innovation within a cluster. Indeed, at the end of the third cycle, the TV Association became the project leader and found new sponsors to institutionalize the solution (fourth cycle). As underlined by the R&D director of one of the IT firms in the cluster: "the portal gives information on actors' positioning. It also allows one to discover and understand partnerships' competencies. The most important aspect is that the portal serves to identify domains where actors are complementary. For example, we want to develop a user approach in the RFID domain, and some local actors are suppliers. The portal is instrumental in developing this approach".

Moreover, in 2008 @ctis-enginerie, a local SSII, bought the licence to exploit the KMP portal. Their website[1] describes the capabilities of the KMP portal as follows: "The KMP tool is a new approach to skill management and to facilitate partnership detection in a network, through the development of collective competencies and a real mapping of the competence center".

4. Discussion and conclusion

Earlier in this paper, we defined design science research as a way to produce new knowledge regarding both a design process and a design product. From this perspective, our study contributes to the literature in three ways, discussed in the remainder of this section.

4.1. Design process: critical success factors for designing a collaborative IOS

Volkoff et al. (1999) focus on the varying role of leadership for successful collaborative IOS development and implementation. Kumar and van Dissel (1996) outlines the historic roots of network structure and its dynamic nature but do not give clues on how to design an IOS. We extended these approaches by identifying critical success factors (CSF) for designing collaborative IOS. These critical success factors are underpinned by the integrative design methodology developed.

CSF1: building scenarios of use

In the HCI field, scenarios of use are 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, scenarios of use often address a narrow work context: classroom, cockpit, and office … For a collaborative IOS, the

[1] See their web site on http://www.actis-ingenierie.com/versiongb/gbtitre3.htm

relevant context is a wider one: the social system and its structural properties. Thus, we propose to complement interaction scenarios of use (HCI approach) with environmental scenarios (structurational approach -Orlikowski, 2000-) -for more detail see Pascal and Rouby, 2006-.

CSF2: relying on ontologies

A semantic representation of information allows for more precise research and increases the degree of answer liability. Ontologies also improve the retrieval of knowledge because they can focus the results on a specific subset and then reduce the set of results (Nevo and Wand, 2005) or conversely can enlarge it if necessary. Ontologies also allow to acknowledge different points of view held by spatially distributed and heterogeneous actors. In addition, ontologies allow knowledge to become more specialized or differentiated among members even in context where members in different groups not share concepts to describe the contents of knowledge.

CSF3: identifying spokespeople

Due to the mobilization of different spokespeople throughout the various stages of the design process, the network supporting the system expanded, allowing a dialectical process to be maintained, which fostered the users' interest and knowledge creation. To this end, using and embedding the artefact in the actual professional practices was essential for reaching compromises between the various actors of the cluster.

CSF4: trying out the artefact in users' practical settings

This was an opportunity to test the designers' working hypotheses, revealing their consequences and thereby possibly enriching, changing or falsifying them. In this respect, 'practising' the design tends to improve the pragmatic validity (Worren et al., 2002) of the underlying knowledge.

CSF5: building shared mental models which act as boundary objects

Our study underlines the specific role of the material artifacts (prototype) produced in each design cycle: they structure the design process over time, foster the emergence of compromises between actors and mutual learning processes. As boundary objects, these material artifacts play a critical role in negotiating and sealing compromises and as such in the success of the collaborative IOS.

4.2. Design product: design requirements for a system that supports knowledge creation in a multi-actor cluster with a broad scope of technologies

The findings from the KMP project suggest that the design product is composed of interdependent and complementary design propositions governing the system features.

Indeed, for a collaborative interorganizational knowledge management system, the system features must include:

- a map of competencies – defined in terms of action, resources, deliverables, and business activity– to reinforce opportunities to exchange and combine knowledge; this map of competencies can rely on ontologies to improve the search process.
- a common space representation, which specify the role of the actors -stakeholders, facilitators and support organizations - and identify similar and complementary competencies to reinforce identity and foster motivation to exchange and combine knowledge;
- an evaluation of the degree of similarity and complementarity of competencies to reinforce the capacity to anticipate the value created through exchange and combination.

Here, the iterative process served to make the set of system features sufficiently generic to be used in other clusters. Indeed, a French health care cluster recently adopted a similar set of interventions (Semionoff-Bru, 2008).

4.3. Improvement of kernel theories: identity as a key factor for innovation

Our study highlights the importance of identity management and provides some new insights into ways to reinforce this identity. Romanelli and Khessina (2005) showed that cluster identity is obtained from the personal identification of individuals that affect their perceptions of similarity or membership in groups. Sammarra and Biggiero (2001) extended this conception by advocating that, in the organizational cluster context, social interaction may also enact identification processes based on perceived complementarities. However, these authors outline that complementarity is a cognitive basis of categorization that is less immediate than similarity, such as sharing goals and mutual needs.

During the KMP project, the iterative design of the common space representation allowed the TV members' perception of complementarity to progressively develop, and as such, the different artefacts led to knowledge translation (Markus et al., 2002) as well as knowledge creation (Pascal et al., 2013). Indeed, both the iterative design and the diversity of actors increasingly involved stimulating new ideas and synergies with the designers, which resulted in the emergence and the enrichment of the complementarity concept. Finally, a clear definition of the latter improved the analysis of generative mechanisms. Numerous researchers showed that identification affected trust, members' commitment and citizenship behaviour (Kogut, 2000; Owen-Smith and Powell, 2004; Romanelli and Khessina, 2005;

Sammarra and Biggiero, 2001). As such, our study connected identity with the anticipation capability.

Limitations and Conclusions

This study had several limitations. First, the design theory developed in this study has not yet been fully tested in another setting with the same class of problems. This means that there is no direct evidence regarding the generalization of the design propositions used for mapping competencies within a cluster, as was the case in TV. Second, the KMP solution did not satisfy the fourth condition of knowledge creation, *i.e.* the combinative capabilities, whereas recent work has emphasized the role of these combinative capabilities, especially in case the cluster is characterized by a complex knowledge base (Carrincazeaux, 2001; Sorrenson, 2006).

Notwithstanding these limitations, the approach developed in this paper opens up new avenues of research and understanding of how new practices are created in geographical clusters. The KMP project suggests design-oriented scholars may be able to engage directly in creating new practices in multi-stakeholder settings. It also suggests that the effectiveness of this type of design project arises from a deliberate focus on articulating design propositions as well as engaging users in trying out prototypes. Moreover, design science research serves to enrich our understanding of the identity cluster concept. As such, it provides new insights into both the role of identity as a *generative mechanism* of knowledge creation within a cluster and on the *interventions* that are instrumental in creating and developing a cluster's identity.

References

Akrich, M., Callon, M., Latour, B. 2002. The key to success in innovation, International Journal of Innovation Management 6(2) 207-225.

Arrègle, J.-L., Amburgey, T. Dacin, T. 1998. Le rôle des capacités organisationnelles dans le développement des réseaux d'entreprises: Une application aux alliances Finance Contrôle Stratégie 1: 7-25.

Avison, D.E., Taylor, V. 1997. Information Systems Development Methodologies: A Classification According to Problem Situation, Journal of Information Technology 12 (1) 73-81.

Baskerville, R. 2008. What design science is not, European Journal of Information Systems 17, 441-443.

Boland, R. J., Collopy, F. 2004. Managing as designing. Stanford, CA: Stanford University Press.

Butler, T., Feller, J., Pope, A., Emerson, B., Murphy, C. 2008. Designing a core IT artefact for Knowledge Management Systems using participatory action research in a government and a non-government organization, The Journal of Strategic Information Systems 17: 249-267.

Capaldo, A. 2007. Network structure and innovation: The leveraging of a dual network as a distinctive relational capability, Strategic Management Journal 28: 585-608

Carrincazeaux, C. 2001. Une évaluation du rôle de la proximité dans la coordination des activités de R&D des firmes, Revue d'Economie Régionale et Urbaine 1 : 53-74.

Castells, M., Hall, P. 1994. Technopoles of the World: The making of 21st Century Industrial

Complexes. London: Routledge.
Cook, P., Huggins R. 2003. High-technology clustering in Cambridge (UK) in The institutions of local development. Fabio Sforzi (eds), 51-74. Aldershot, Ashgate.
David, A. 2000. La Recherche-Intervention: Cadre Général pour la Recherche en Management? in Les Nouvelles Fondations des Sciences de Gestion: Eléments Epistémologiques de la Recherche en Management. A. David, A. Hatchuel and R. Laufer (eds.), 193-213. Paris: Vuibert-Fnege.
Denyer, D., Tranfield, D., van Aken, J.E. 2008. Developing design propositions through research synthesis, Organization Studies 29, 393-414.
Doherty, N.F., Terry, M. 2009. The role of IS capabilities in delivering sustainable improvements to competitive positioning, Journal of Strategic Information Systems 18, 100-116.
Dyer, J.H., Singh, H., 1998. The relational view: Cooperative strategy and sources of inter-organizational competitive advantage, Academy of Management Review 23, 660-679.
Eckert, C., Boujut, J.-F. 2003. The role of objects in design co-operation: communication through physical or virtual objects. Computer Supported Cooperative Work 12(2) 145-151.
Foss, J.F. 1999. Networks, Capabilities, and Competitive advantage, Scandinavian Journal of Management 15, 1-15.
Gandon F., 2001. Engineering an Ontology for a Multi-Agents Corporate Memory System, Conference ISMICK.
Goldkuhl, G. 2004. Meanings of pragmatism: Ways to conduct information systems research, Action in Language, Organisations and Information Systems.
Gupta, A., Mattarelli, E., Seshasai, S., Broschak, J. 2009. Use of collaborative technologies and knowledge sharing in co-located and distributed teams: Towards the 24-h knowledge factory, Journal of Strategic Information Systems 18, 147-161.
Håkansson L., 1993. Networks as a mechanism to develop resources, In Beije P., Groenewegen J., Nuys O. 1993, Networking in Dutch Industries, Garant, 207-223.
Hatchuel, A. 1994. Les savoirs de l'intervention en entreprise, Entreprises et Histoire 7, 59-75.
Henderson, K. 1999. On line and on paper: Visual representations, visual culture and computer graphics in design engineering. Boston: MIT Press.
Hevner A., 2007. The three cycle views of design science, Scandinavian Journal of Information Systems 19(2) 87-92.
Hevner A.R., March, S.T., Park, J., Ram, S., 2004 Design Science in Information Systems Research, Management Information Systems Quarterly 28: 75-106
Hodgkinson, G.P., Healey, M.P. 2008. Toward a (pragmatic) science of strategic intervention: Design propositions for scenario planning, Organization Studies (29)3 435–457.
Hooker J., 2004. IS Design Theory Possible?, Journal of Information Technology Theory and Applications 6(2) 73-82.
Iansiti, M., Levien, R. 2004. The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation and Sustainability. Boston, MA: Harvard Business School Press.
Jarke M., Tung Bui X., Carroll J.M.. 1998 Scenario Management : An Interdisciplinary Approach, Requirements Engineering, 3: 155-173.
Jelinek, M., Romme, A.G.L., Boland, R.J. 2008. Introduction to the special issue: Organization studies as a science for design - creating collaborative artefacts and research, Organization Studies 29(3) 317-330.
Keeble, D., Lawson, C., Moore, B., Wilkinson, F. 1999. Collective learning processes, networking and 'institutional thickness' in the Cambridge region, Regional Studies 33: 319-332.
Kogut, B. 2000. The network as knowledge: generative rules and the emergence of structure. Strategic Management Journal 21, 405-425.
Kogut, B., Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. Organization Science 3, 383-97.
Kumar, N., L. W. Stern, and J. C. Anderson (1993). 'Conducting interorganizational research using key informants', Academy of Management Journal, 36, pp. 1633–1651.
Krafft, J. 2004. Entry, Exit and Knowledge: Evidence from a cluster in the info-communications, Research Policy 33(10) 1687-1706.
Latour, B. 1986. The powers of association. In J. Law (ed.), Power, action and belief: A new sociology

of knowledge? Sociological Review Monograph 32: 264-280. London: Routledge & Kegan Paul.
Law, J., Callon, M. 1988. Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change. Social Problems 35 (3) 284-297.
Lazaric N, Longhi C and Thomas C (2008) Gatekeepers of Knowledge versus Platforms of knowledge: from potential to realized absorptive capacity, Regional Studies 42(6), 837-852.
Lindgren R., Henfrdsson, O., Schultze, U. 2004. Design principles for competence management systems: a synthesis of an action research study. MIS Quarterly 28(3) 435-472.
Löfsten, H., Lindelöf, P. 2002. Science parks and the growth of new technology-based firms: academic–industry links, innovation and markets. Research Policy 31, 859– 876.
Longhi, C. 1999. Networks, collective learning and technology development in innovative high technology regions: The case of Sophia Antipolis, Regional Studies June, 33 (4): 333-342.
March, S.T., Smith, G.F. 1995. Design and Natural Science Research on Information Technology. Decision Support Systems 15(4) 251-266.
Markus, M.L., Majchrzak, A., Gasser, L., 2002. A design theory for systems that support emergent knowledge processes, MIS Quarterly 26: 179-212.
Mohrman, S. A. 2007. Having Relevance and Impact: The Benefits of Integrating the Perspectives of Design Science and Organizational Development, Journal of Applied Behavioral Science 43: 12-24.
Moran, P., Ghoshal, S., 1996. Value Creation by Firms. In Keys J.B., Dosier L.N. eds. Academy of Management Best Papers Proceedings: 41-45.
Nahapiet, J., Ghoshal, S. 1998. Social capital, intellectual capital, and the organizational advantage, Academy of Management Review 23(2) 242-266.
Nevo D and Wand Y (2005) Organizational memory information systems: a transactive memory approach, Decision Support Systems 39, 549-562.
Newell S, Robertson M, Scarbrough H and Swan J (2009) Managing knowledge work and innovation, Basingstoke ; New York : Palgrave Macmillan.
Owen-Smith, J., Powell Walter W., 2004, Knowledge Network as Channels and conduits : The Effects of Spillovers in the Boston Biotechnology Community, Organization Science 15(1) 5 –21.
Pandza, K. and R. Thorpe (2010). 'Management as design, but what kind of design? An appraisal of the design science analogy for management', British Journal of Management, 21/1, pp. 171-186.
Pascal A, Thomas C and Romme AG (2013) Testing a human-centered and science-based design methodology, British Journal Management 24(2), 264-280.
Pascal, A., Rouby, E. 2006. Construire des scénarios d'usage : une approche gestionnaire - Le cas KMP -, Actes de la SdC 2006 (Semaine des Connaissances), Tome 2, Éditeurs : Rémi Lehn, Mounira Harzallah, Nathalie Aussenac-Gilles, Jean Charlet.
Plsek, P., Bibby, J., Whitby, E. 2007. Practical Methods for Extracting Explicit Design Rules Grounded in the Experience of Organizational Managers. Journal of Applied Behavioral Science 43: 153-170.
Richardson, G. B. 1972. The Organisation of Industry. The Economic Journal September: 883-896.
Romanelli, E., Khessina, O.K. 2005. Regional Industrial Identity: Cluster Configurations and Economic Devolpment, Organization Science, 16(4) 344-358.
Romme, A. G. L. 2003. Making a difference: Organization as design. Organization Science 14: 558-573.
Romme, A. G. L., Endenburg, G. 2006. Construction principles and design rules in the case of circular design, Organization Science 17: 287-297.
Rouby, E., Thomas, C. 2004. La codification des compétences organisationnelles: l'épreuve des faits, Revue Française de Gestion 149 (2): 51-68.
Sammarra, A., Biggiero, L. 2001, Identity and Identification in Industrial Districts, Journal of Management and Gouvernance 5: 61-82.
Shawney M., Prandelli E., 2000. Communities of Creation: Managing Distributed Innovation In Turbulent Markets, California Management Review 42(4) 24-54.
Semionoff-Bru, Thierry 2008. Interview available at http://www.actis-ingenierie.com/titre3.htm
Schultze, U., Boland, R. J.. 2000. Knowledge management technology and the reproduction of knowledge work practices, The Journal of Strategic Information Systems 9:193-212.
Sorenson, O., Rikvin, J.W., Fleming, L. 2006. Complexity, networks and knowledge flow, Research

Policy 35. 994-1017.
Van Aken, J. E. 2005. Management research as a design science: Articulating the research products of mode 2 knowledge production in management, British Journal of Management 16: 19-36.
Van de Ven, A. H., Johnson, P. E. 2006. Knowledge for theory and practice, Academy of Management Review 31: 802-821.
Van de Ven, A.H. 2005. Running In Packs To Develop Knowledge-Intensive Technologies. MIS Quarterly 29:365-377.
Volkoff, O., Chan Y.E., Newson, E.F.P. 1999. Leading the development and implementation of collaborative interorganizational systems. Information & Management 35:63-75.
Volkoff, O., Elmes, M.B., Strong, D.M.. 2004. Enterprise systems, knowledge transfer and power users, The Journal of Strategic Information Systems 13:279-304.
Walls, J. G., Widmeyer, G. R., El Sawy, O.A.. 2004. Assessing information system design theory in perspective: How useful was our 1992 initial rendition, JITTA: Journal of Information Technology Theory and Application 6:43-58.
Winter, R., 2008. Design Science in Europe, European Journal of Information Systems 17: 470–475.
Worren, N. A., Moore, K., Elliott, R. 2002. When theories become tools: Toward a framework for pragmatic validity. Human Relations, 55: 1227-1250.