Episteme or practice? Differentiated Communitarian Structures in a Biology Laboratory

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Abstract. This paper explores the different social structures coexisting within a biology laboratory. This work draws upon an empirical study and the results are analysed using the social network analysis toolbox. We evidence that actors form links between them in order to carry out cognitive activities. Depending on the content of this activity, resulting networks can take different shapes. When dealing with scientific knowledge, actors tend to form an epistemic community, whereas they form a community of practice when they seek to enhance their skills in setting experiments. Moreover, these two structures are connected by means of boundary objects and boundary spanners.

Introduction

Communities have recently become a prominent unit of analysis for understanding knowledge exploration, sharing and transmission in and among organizations [Bowles and Gintis, 2000]. “By community we mean a group of people who interact directly, frequently and in multi-faceted ways. People who work together are usually communities in this sense, as are some neighborhoods, groups of friends, professional and business networks, gangs, and sports leagues.

The list suggests that connection, not affection, is the defining characteristic of a community” [Bowles and Gintis, 2000: 3].

As links within the communities are specific, and more tightly defined than with the environment, this notion proved especially relevant to understand to learning and knowledge creation. Indeed, communities understood as specific governance structures are deemed particularly relevant to coordinate collective knowledge creation efforts. Communities articulate tacit, fuzzy, ever-moving information flows and knowledge.

However, there is no such thing as ‘the’ community with specific, clear and characteristic features. The recent surge in the literature on studies of communities put emphasis on multiple various aspects of their organization, management, boundary dynamics and social relationships [Bowles and Gintis, 2000]. Communities of practice [Lave and Wenger, 1990], epistemic communities [Knorr Cetina, 1999], virtual communities [Alstyne and Brynjolfsson, 1996], communities of creation [Sawney and Prandelli, 2000], strategic communities [Stork, 2000], among others, all these communities might populate diverse organizational contexts.

This paper contends that there is a strong need to clarify what is called organizational community and what are the main characteristics of diverse communities. Especially, this paper attempts to distinguish and relate the two notions of epistemic community and community of practice. We chose to focus on these two notions for two reasons. First, there is a stronger field of the literatures devoted to them than to the other ones. Second, these communities are explicitly knowledge-intensive[1]. Moreover, the proximities and distances between these two notions have not yet been thoroughly investigated. This paper therefore aims at differentiating and relating epistemic communities (ECs) and communities of practice (COPs).

Based on a case study carried out in a French biology laboratory, analysis was twofold. First, we distinguish the two types of community, namely EC and COP. We claim that both kinds of communities contribute to knowledge creation and maintenance, but that they display distinctive features in terms of their social structures, the type of knowledge they handle and their activities. Second, we put forward that knowledge creation occurring within the laboratory as a whole stems from the interplay between these two structures.

This paper is organized as follows. First, we theoretically present the notion of community and then we detail epistemic communities and communities of practice. The next section is devoted to the methodology of this research. Then, the ‘LAB’ case study is described. Next, using social network analysis, we draw two social structures that advance the understanding of the distinction between

[1] We do not address the case of virtual communities, since the concept encompasses a large diversity of realities: many virtual communities are not concerned by learning or knowledge creation and therefore fall out of the scope of this paper.

epistemic community and community of practice. We finally try to understand how these two structures are intertwined and what are the outcomes of this interplay.

A first step toward the disentanglement of organizational communities

Many forms of communities can be identified within the literature, both in the realm of economics and of management studies. Given this diversity, authors have decided to focus on cognitive communities, that is, communities engaged in one way or another in knowledge creation processes, and even more precisely on two specific kinds of cognitive communities deemed to be the most relevant in terms of creation of knowledge “as usual” within the firm. It is, however, possible to lay out some important features common to many types of cognitive communities one can find in the literature.

Cognitive communities share a common ground that differentiates them from other types of communities (e.g. communities of interest, social communities, etc.). Cognitive communities rely on myriad of interactions between individuals sharing a common cognitive objective. Their commitment to this objective is paramount for it determines the degree of members’ involvement in the collective thrive of the community.

Epistemic communities and communities of practice are the most relevant types of groups for the purpose of this paper, since they are the place where knowledge creation occurs on a regular basis, independently of any hierarchical decision. The key point, within the scope of this paper is that epistemic communities are truly oriented toward new knowledge creation, whereas communities of practice are oriented toward the achievement of an activity. In this latter case, knowledge creation is an unintended spill-over.

Epistemic Communities

Epistemic communities can be defined as small groups of “agents working on a commonly acknowledged subset of knowledge issues and who at the very least accept a commonly understood procedural authority as essential to the success of their knowledge activities” [Cowan et al., 1998]. Epistemic communities can thus be defined as a group of agents sharing a common goal of knowledge creation and a common framework allowing the shared understanding of this trend. The goal of epistemic communities is thus simultaneously outside and above the community’s members. The concept of "epistemic communities" was developed in particular in the realm of international relations [Haas, 1992; Adler and Haas, 1992]. Using this concept to address the issue of codification of knowledge, Cowan et al. [1998] suggest that any codification activity implies the existence of codes that are understandable by the communicating actors.

What defines an epistemic community is thus the existence of a procedural authority that can be explicit or not. However, it must be different from the kind of authority held by a "guru" to ensure certain autonomy of the members. Moreover, the procedural authority conveys the idea of progress toward the cognitive goal set by the community. The belonging of members will thus be evaluated with respect to this procedural authority. It should be noted that this procedural authority could a priori emerge from the interactions among members. In that case, the organizational closure is either realized, or imposed from the outside and then not realized. In the former case, the epistemic community is self-organized and then close in this respect to a community of practice. This remark is important since it shows evidence of the possibility for one form of community to evolve into the other.

Epistemic communities are structured around a goal to be reached and a procedural authority endowed by themselves (or with which they were endowed) to fulfill that goal. Notions of autonomy and identity are thus weaker than in the case of communities of practice (see below), thus favoring the group's creativity [Leonard-Barton, 1995]. Thus, the community increases its ability to seize future opportunities. This form of organization spawns knowledge creation by favoring the synergy of individual varieties. We find here the principle of "required variety" stated by Ashby [1956]. Individuals accumulate knowledge according to their own experiences. The quality of this knowledge depends on two factors. The first is the variety of individual experiences in interaction. The second factor is the "knowledge of the experience". This is consistent with the idea of a rational ability of experience feedback within which the validation is made according to the procedural authority: what is evaluated is the contribution of the agent to the cognitive goal with regard to the criteria set by the procedural authority.

Because of the heterogeneity of the agents, the objective of knowledge creation for the sake of knowledge, the first task of epistemic communities is to create a "codebook". Hence, knowledge circulating within epistemic communities is explicit (but not codified since it remains mainly internal to the community [Baumard, 1999]. Because of the lack of deeply shared values, it appears that the knowledge creation mode is much like a form of externalization (conversion of tacit into explicit knowledge [Nonaka and Takeuchi, 1995].

Knowledge creation is certainly the main goal of epistemic communities is knowledge creation. However, this goal is itself subordinated to another one: convincing the outer world that the position it holds is right.

Validation of the cognitive activity of an agent is made with respect to the procedural authority. What is evaluated is the contribution to the endeavor toward the goal to be reached, according to the criteria set within the procedural authority. Within an epistemic community, agents are bound together by their commitment to enhance a particular set of knowledge. The recruitment rule is thus defined with regard to the contribution an agent makes to fulfill this goal (this goal is likely to be partly given and partly emergent [Blackler and McDonald, 2000])[2].

Communities of Practice

The concept of communities of practice was introduced by Lave and Wenger [1991] who, by focusing on individuals' practices, identified groups of persons engaged in the same practice, communicating regularly with one another about their activities. Members of a community of practice essentially seek to develop their competencies in the practice considered. Communities of practice can then be seen as a means to enhance individual competencies, they are oriented toward their members [Lave and Wenger, 1991; Brown and Duguid, 1991]. This goal is reached through the construction, the exchange and the sharing of a common repertoire of resources [Wenger, 1998].

Wenger [1998] and Brown and Duguid [1991; 1998] state that self-organization is an essential characteristic of communities of practice. According to Lesourne [1991], self-organization is the ability of a system to acquire new properties by organizing itself or by modifying by itself its own organization [Lesourne, 1991]. Self-organization confers to the system an adaptive ability to evolve without any constraint of authority nor any determinism. The system is then autonomous and sets a boundary with respect to the other functions of the firm. It creates a sort of “organizational closure” in the terminology of the theory of self-organization. This idea is important since it underlines the cross functional nature of communities of practice.

More precisely, autonomy and identity of communities, the key characteristics of self-organization allow the collective acquisition and processing of stimuli from the environment [Wenger, 1998; Dibiaggio, 1998]. Identity and autonomy are essential for the agent to define herself with respect to her environment and for the members of the community to behave collectively.

The self-consciousness is also visible in the mutual commitment of the community. It is built around activities commonly understood and continually renegotiated by its members. A community’s member feeds it with her experience and, in turn, relies on the knowledge capitalized by the community to carry out her activity. These processes take the shape of “war stories” [Brown and Duguid, 1998] that members tell when they gather. They thus develop a jargon understandable by the members only. It is thus a mutual commitment that binds

[2] Epistemic communities emerge in uncertain context calling for the creation of a new paradigm (which is not the case for communities of practice) [Haas, 1992; Whiteneck, 1996]. We are then close to the community of young researchers overcoming the old paradigm in Kuhn’s theory [1962].

agents in a social entity, ensure cohesion of the community and recruitment of new members.

Lave and Wenger [1991] interpret the practice of these communities as the vector of learning, which is in turn the building of an individual entity. Hence, the evaluation of an individual is made by the community of practice as a system and is focused both on the values adopted by the individual and on the progress made in her practice, the two being co-constitutive.

This implies that members of a community of practice do not all contribute in the same manner to the cognitive activities [Wenger et al., 2002]. At the heart of a community of practice lies a hard core made of one or few coordinators. Around them, active collaborators constitute the first level of participation. The second degree is made of more peripheral actors, participating in the activity of the community but at a lower degree of commitment.

Within communities of practice, the privileged knowledge is thus essentially the know-how [Brown and Duguid, 1991], which is tacit and socially localized. The nature of knowledge is due to the objective and the structure of the communities of practice. As a result, the community tends to send no messages toward the outer world. Messages are almost exclusively exchanged among the members of such a community.

Objectives of this research

This research aims at differentiating and relating the notions of epistemic community (EC) and community of practice (COP). It endeavors to determine whether or not they correspond to distinct realms of organizational life and to understand how agents relate to these two kinds of structuring. It seeks to develop general propositions regarding the separation and relation between the two kinds of communities. Such conceptual distinction is important on theoretical as well as on applied grounds.

Theoretically, attempting to untangle ECs and COPs is necessary to determine whether there should be two different concepts. Moreover, if epistemic communities and communities of practice concern aspects of organizing that partially overlap, it becomes relevant to examine what makes them close and yet different.

On the more practical side, questionings multiply today as to how to support communities in organizations. If there are deep differences among communities, then these distinct groups should require different ways to be encouraged and managed and these ways might be inconsistent. Differentiating and relating epistemic communities and communities of practice could therefore prove useful to make explicit their respective managerial challenges and suggest paths to support them.

In order to differentiate and relate ECs and COPs, this research investigated the social structure(s) of a specific group that could a priori be indifferently considered as an ideal context for EC and COP. The structural analysis sought to determine if the two communities emerged, in which regards they were different and how members of these two communities acted in relation to one and / or the other one.

Methodology

Research design and choice of the research setting

We chose to study a single field, a biology laboratory, henceforth called 'the LAB'. The single case research design made it possible to deeply investigate the field and to underscore its collective processes and structuring. In particular, we needed to access the main work practices as well as the internal and external relationships of a group whose features were close to organizational communitarian ones.

Of course, as communities are informal groups that do not have clear and fixed boundaries, we could not be sure before investigating it that the studied context was a community. The fuzzy nature of communities made it especially important to distinguish field characteristics that encourage the emergence of communities. The criteria we selected concerned the size, the location, organization and overall mission of the field (cf. table 1). None of them independently warranted the presence of communities, but their coincidence made us presume of a community-friendly environment.

Criteria	**Presumption of community-friendly environment**	**LAB's case**
Size	*Small size*: Most members know each other.	13 members in the LAB.
Location	*Collocation*: Members interact on a daily basis.	All LAB members work full-time in the same building.
Organization	*Common overall activity* and preeminence of an informal organization.	All LAB members work in the same field of activity, in genetic biology.

Table 1: A community-friendly environment

Moreover, in order to examine the potential differences and similarities between epistemic communities and communities of practice, the field was to present potential characteristics of both kinds of communities. We selected this case because, according to its members' practices *and* knowledge basis, it could be interpreted both as a community of practice and as an epistemic community (cf. table 2), with no way to label it a priori nor exclusively one way or the other.

	Community of practice	**Epistemic community**
Attributes	Group whose members develop close work practices, for some similar and for some complementary.	Group devoted to the advancement of specific knowledge, for instance scientific.
Example from the literature	Copiers' repairers [Orr, 1996]	Physicians from [Knorr Cetina, 1999]
LAB's case	LAB's members worked closely and on the same machines.	LAB's members devoted to the advancement of genetic biology.

Table 2: Epistemic communities and communities of practice: empirical attributes

Data collection and analysis

To get a simultaneously broad and fine-grained vision of the LAB's organization, we triangulated diverse sources of observations. One of the authors became a participant observer in the field. While these day-long sessions of participant observation over a period of two months were not sufficient a truly dynamic understanding of the case, they made us reasonably acquainted with the idiosyncrasies of the context. In addition to this participant observation, we also consulted the archives of the LAB as well as its bibliographical and patents records. Finally, all LAB's members were semi-structured interviewed. Interviews lasted from 45 minutes to 2 hours. They were tape-recorded and transcribed. Conversations concerned the ways LAB's members worked, interacted and exchanged on a daily basis. These diverse qualitative sources of observations were fused to describe the case study presented below.

We complemented this first exploratory stage of the case by systematizing the interviews' analysis. From each interviewee's transcripts we extracted the main relationships the agents' had with her or his colleagues to draw the overall network of communications[3]. Then, we distinguished between two types of relationships (respectively involving exchanges regarding the making of experiments or scientific advancement). Such distinction represented a mean for us to try to distinguish, and then analyze, the two potential kinds of communities. The results of this empirical work are presented below.

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[3] We used the R software [Ihaka and Gentleman, 1996].

The LAB's case study

The LAB (officially called Laboratory of Viral Genetics and Biosecurity) is a small research center located in a French rural region geographically close to two universities, U1 and U2. The LAB is related to a 'zoo-hub', local association of research centers and agricultural firms devoted to the improvement of animals (especially bovines and chicks)' health.

Members of the LAB investigate two main sets of themes. Some researchers work on determining the genome of emerging viruses and on evaluating their bio-security. Others study viral and plasmatic vaccine vectors. Most financial support of the LAB's activity comes from the parent institution (the AFSSA) and from research programs sponsored by various institutions. In particular, the LAB depends on research programs financed by the INSERM[4] and by the European Union. At the time of this study (mid- 2002), thirteen people (scientists, technicians and one administrative person) work full-time for the LAB. They all institutionally belong to the AFSSA.

Name	**Status**	**Scientist / Technician**	**Length of service[5]**	**Type of contract**
André	Research director	Scientist	18 years	Permanent contract
Patrick	Research director	Scientist	10 years	Permanent contract
Philippe	Qualified technician	Technician / sc	18 years	Permanent contract
Claire	Qualified technician	Technician / sc	10 years	Permanent contract
Yannick	Post-doc	Scientist	3 months	Fixed-term contract: 36 months
Christophe	Post-doc	Scientist	2 months	Fixed-term contract: 18 months
Daniel	Post-doc	Scientist	1 month	Fixed-term contract: 18 months
Frédéric	Doctoral student	Scientist	4 months	Fixed-term contract: 36 months
Véronique	Qualified technician	Technician	1 year	Fixed-term contract: 24 months
Aurélie	Qualified technician	Technician	6 months	Fixed-term contract: 12 months
Annie	Technician	Technician	18 years	Permanent contract
Renée	Technician	Technician	4 years	Permanent contract
Ludovic	Administrative assistant	NA	6 months	Permanent contract

Table 3: LAB's members

Because of the lack of permanent financial resources of the laboratory, most scientists are hired on a fixed-term contract basis. On the other hand, most technicians are hired on a permanent basis. They have been working for a longer

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4 INSERM: Institut National de la Santé Et de la Recherche Médicale (National Institute of Health And Medical research).

5 Length of service at the moment of investigations (April / May 2002).

period than the scientists and they know that they will stay there for more than one or two years.

The laboratory is organized around its main research projects. At the time of investigations, the scientists are devoted to three main projects. The first one, directed by Patrick, concerns the genome of an emerging virus affecting bovines (let us call it emerging virus), while the two others, supervised by André, treat viral and plasmatic vaccine vectors (henceforward named Vaccine vector 1 and 2). The newly arrived scientists (2 post docs and a doctoral student), according to their previous works and their competencies, were hired by the concerned research directors to pursue these research projects. The third post-doc (Yannick) was hired to work part time on one research project (Vaccine Vector 1, with Daniel) and to develop his own project of implementation of a bio-informatics software in the center. Yannick who has a double competence, as a scientist and as a computing specialist in bio-informatics, was conjointly hired by the LAB and by the local zoo-hub.

	Emerging virus	**Vaccine Vector 1**	**Vaccine Vector 2**
Research director	Patrick	André	André
Participating scientists	Frédéric	Daniel Yannick (part time)	Christophe

Table 4: The LAB main research projects

Scientists devoted to each research project accomplish the bibliographical work needed to document their topic. This takes them approximately 10 to 20% of their time, mostly during pauses in experiments. Scientists also realize scientific manipulations needed to advance their project. Their experimental work entails the design of the experience (aim, methods, timing, required materials) and its actual implementation and follow-ups. Qualified technicians accompany scientists at every stage of experiments: they help them design and realize the manipulations.

It is worth noting that the three research projects are close regarding their subjects and methods. Moreover, all researchers share the same general scientific and experimental knowledge. They benefited from the same initial training in the same sub-field of biology (molecular biology) and got specialized at the doctoral and post-doctoral levels. Therefore, they all have already used the materials that everyone utilizes and they are more or less familiar with each other’s research topics. This point is significant for it makes possible for all scientists to interact concerning their respective scientific projects and experiments.

Moreover, the technicians, whether qualified or not, are not devoted to any research project in particular but they deal with distinct activities. Two of them, Annie and Renée, take care of the laundry service and of the sterilization of equipments. The qualified technicians have missions to help scientists to advance their project. Veronique is working as Claire's assistant and she is specialized in using the sequencer. Aurélie, who is Philippe's assistant, works mainly with the spectrophotometer. Sequencer and spectrophotometer are used, to a certain extent, in the three research projects. Finally, the two greatest lengths of service and the most qualified technicians, Philippe and Claire, are not really specialized in the use of any specific machine. They know how to utilize all of them and have a long experience of scientific manipulations.

Finally, because of the small size of the laboratory, no clear hierarchical and formal structure has been established. The center's features are close to Mintzberg [1979, p.483]'s adhocracy. Every scientist might ask anyone else (either scientist or technician) to help him achieve his/her experiment. To unravel the structure of the laboratory, we built the relationships between agents in terms of who is depending on whom in terms of access to complementary knowledge (figure 1). Since the laboratory can be seen as a knowledge intensive organization, this dependency network matches the overall structural functioning of the LAB. The arrows are oriented from the agent that asks for help to the agents that answers. The thicker is the arrow, the more frequent are the interactions between the pair of agents. In addition, not only individual agents are represented but also institutions with which agents are in contact.

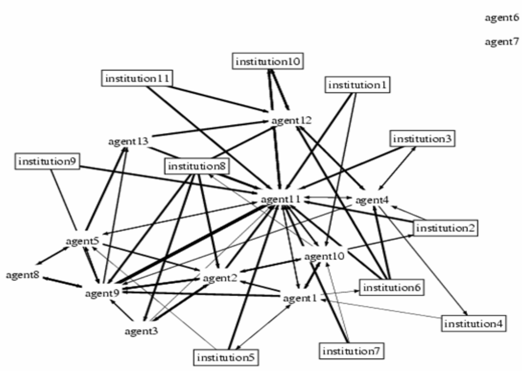

Figure 1: Graph of the structure of total communications

At first sight, the graph shows complex interdependencies between members and there seems to be no clear pattern. To refine our understanding of what occurs in this social structure, one needs to split the graph of the figure 1 in finer categories. More precisely, it appears that two distinct modes of relations can be identified within the lab. On the one hand, particular relationships emerge around the issues related to manipulations, tools, experimental settings, etc. The knowledge mobilized during these interactions is know-how [Lundvall and

Johnson, 1994] centered on the practical dimension involved in research in molecular biology. On the other hand, relationships are created between agents about the scientific dimension itself. By scientific dimension, we mean that part of the research activity that takes the shape of formal knowledge, articles, literature, etc. These two networks of relationships involve the same actors, but they occupy different specific positions and play different roles depending on which mode one considers. According to the definitions established above, we argue that the first mode of relation equates to a community of practice, whereas the second one defines an epistemic community. The following section explores the key differences between these two networks and attempts to draw more thoroughly the distinctions between the two types of communities.

Two observed Network Structures: an Epistemic Community and a Community of Practice

Hypothesis and choice of indicators

We base our analysis of the different structures on four indicators common in social network analysis: indegree, outdegree, closeness and betweenness. Moreover, to reflect the fact that the interactions are of various intensities, they are weighted with weights ranking from 0 to 5. Given a graph G = (I,D) with I the set of vertices and D = {d(i,j)} an adjacency matrix, then the indicators can be defined as follow:

Indegree of an agent in a directed graph is the number of edges that have this agent as arrival point. Formally,

$$N^{+}(v) = \#\{i \in I : d(i,v) \neq 0\}$$

Outdegree of an agent in a directed graph accounts for the number of edges that have this agent as starting point. Formally,

$$N^{-}(v) = \#\{i \in I : d(v,i) \neq 0\}$$

Degrees can be interpreted in terms of the sizes of actors' neighborhoods within the larger structure. In addition, links are weighted and d(i,j) can be greater than one. Since the studied networks display the interdependencies of agents in terms of knowledge, the degrees are indicative of the role of each agent. An agent having a high outdegree would be an agent that requests a lot of help from the other members of the organization. On the contrary, an agent having a high indegree acts as an expert diffusing his/her knowledge towards the other members of the laboratory.

Closeness of an agent can be understood as a measure of the extent to which a given vertex has short paths to all other vertices in the graph; this is one reasonable measure of the extent to which a vertex is in the ``middle" of a given structure. [Wasserman and Faust, 1994]. Closeness of a vertex is defined formally as,

$$C(v) = \frac{|I| - 1}{\sum_{i \in I, i \neq v} g(v,i)}$$

where g(v,i) is the geodesic distance (shortest paths) between v and i (where defined).

Closeness is a measure attached to each node of the graph. An agent having a high closeness is central in the graph in that many paths go through him/her. S/he is then a central actor and a coordinator of the interactions taking place in the social structure.

Betweenness of an agent is a measure of the number of shortest paths between any pairs of agents to which this agent belongs. Hence, high-betweenness vertices lie on a large number of non-redundant shortest paths between other vertices. They can thus be thought of as playing the role of ``bridges" or ``boundary spanners'' within the network [Wasserman and Faust, 1994]. Betweenness differs from closeness in that there is no notion of centrality: an agent may have a high betweenness and a low closeness by being placed in the path between two cliques. We use betweenness precisely to identify these agents that are gateways between two tightly connected subgraphs. In our case, the network presents two types of vertices: individual agents and organizations. We make the assumption that organizations are made of several individual agents. Betweenness is here defined as,

$$B(v) = \sum_{i,j} \frac{\beta n_{iv} \times \beta n_{vj}}{n_{ij}} \quad with\ i \neq j \neq v$$

Where n_{ij} is the number of geodesics between i and j and β is a parameter reflecting the fact that an organization contains several individual agents. As a blunt estimation, we took β equals to the number of individual agents present in the lab under study (i.e. β = 13 if i is an organization, β = 1 if i is an individual agent).

These indicators are here intended to characterize each individual presents in the network. Our objective is to accounts for the different communication structure by analyzing the various roles played by actors in each social setting. To do so, we ran a cluster analysis over these four indicators in order to identify the various populations of roles played by agents in each network. In what follows, we present the two graphs and the roles played by agents in each of these social settings.

Results

The two graphs below represents the structures of communication we explore in this subsection.

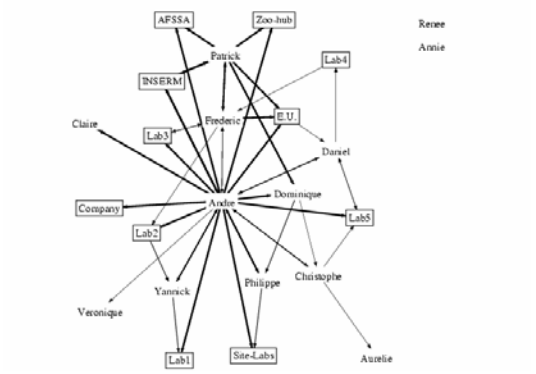

Figure 2- Graph of the structure of communications about science

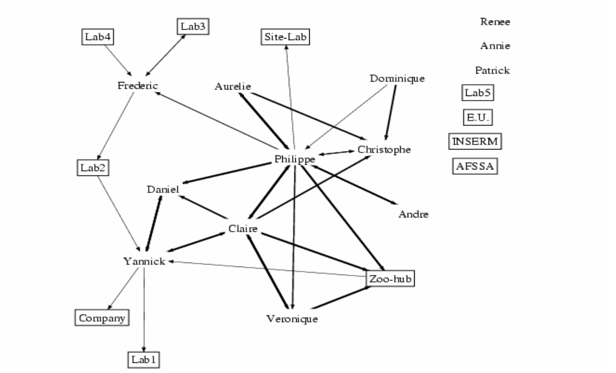

Figure 3- Graph of the structure of communications about manipulations

Network of communications with scientific content

	Indegree	**Outdegree**	**Closeness**	**Betweenness**	**Cluster's composition**
Cluster 1	5.50 (2.12)	8.00 (5.65)	0.26 (0.004)	0.19 (0.02)	Daniel, Frederic
Cluster 2	6.00 (2.94)	4.50 (1.29)	0.24 (0.02)	0.02 (0.04)	Christophe, Philippe Yannick, Dominique
Cluster 3	9.00	29.00	0.25	0.03	Patrick
Cluster 4	1.40 (2.07)	0.00 (0)	0.04 (0)	0.00 (0)	Claire, Veronique Aurelie, Renee Annie
Cluster 5	17.00	73.00	0.31	0.45	Andre

Table 5- Average values related to the different types of agents present in the graph of scientific communications (means (standard deviation))

The clusters only include individual agents. However, measures were computed taking into account organizations. We find a divisive coefficient of 0.83, which indicates a good discriminatory power of the chosen variables. Cluster 4 appears as irrelevant for scientific communications network and contains agents not participating directly in scientific knowledge production. The agent captured in cluster 5 clearly stands out of the population of agents. Indeed, he is the one having the highest degrees, the highest closeness and the highest betweenness. This agent appears as the leader of the community in the sense of

Knorr-Cetina [1999]. According to her, leaders in scientific labs are at the center of communications network and participate actively in every scientific work taking place in the lab (which is here the case, as indicated by the closeness and the degrees of the agent). Moreover, these agents also play the role of spokespersons for the lab toward the outside. This is the case here, as shows the high betweenness of the agent. In our theoretical framework, this agent is the one endowed with procedural authority, coordinating the work and indicating what way to pursue in research.

Cluster 1 and cluster 2 contains agent participating actively in scientific knowledge production within the lab, as demonstrate the values of degrees and closeness. However, they play little role in the circulation of knowledge, as their low betweenness indicates. These agents are thus encapsulated in the local social structure, participate actively in lab's projects, but do not play the role of spokespersons for the lab. The higher level of the betweenness of cluster 1 compare to cluster 2 may indicate that the former is constituted of more confirmed scientists that gained enough acknowledgement by their peers to start to communicate toward the outside and to be in charge of one of the projects of the lab. These results are in agreement with the work of Girvan and Newman [2001] exploring the structure of scientific collaborations.

By construction, this network contains scientific knowledge, explicit by nature. Moreover, the analysis highlights the existence of an agent endowed with a procedural authority. This procedural authority is the glue holding the members in collective thrive (as revealed by the interviews). Lastly, the leader also acts as a spokesperson and communicates the results of the lab toward the outer world. This social structure thus fully qualifies as an epistemic community as we defined it above.

Network of communications about manipulations

	Indegree	**Outdegree**	**Closeness**	**Betweenness**	**Cluster's composition**
Cluster 1	7.33 (5.42)	5.83 (3.06)	0.09 (0.004)	0.00 (0.001)	Daniel Christophe Veronique Aurelie Andre Dominique
Cluster 2	4.00	2.00	0.09	0.22	Frederic
Cluster 3	15.50 (2.12)	29.50 (3.53)	0.10 (0)	0.16 (0.02)	Claire Philippe
Cluster 4	11.00	10.00	0.09	0.30	Yannick

Table 6: Average values related to the different types of agents present in the graph of communications related to manipulations (means (standard deviation))

We find a divisive coefficient of 0.84, which indicates a good discriminatory power of the chosen variables. The number of degrees indicates that the level of communication is high, as was the case in scientific communications network. In particular, cluster 2 display high values for indegree and outdegree, suggesting that agents contained in this network are solicited often regarding experiments. However, compared to scientific communications network, the values of closeness are much lower, indicating that in this case, no agent play a really central role in the overall network coordination. This suggests that although some agents are able to communicate a lot about practice of experiments, they do not play a role of leader in the network of communications about manipulations. Also, betweenness is more spread among agents, pointing that circulation of ideas depends on more individuals than in the previous case. The conjunction of these two facts evidence that communication toward the outer world is not carried out by one single individual, but rather by several ones not standing at the core of the network.

The communications in this network deal with know-how involved in the conduct of experiments. The structure of the network with highly skilled actors at its center and less experienced ones at its periphery is typical of a community of practice. Lave and Wenger [1991] insist on the fact that in a community of practice, agents move from the periphery to the core of the community as they become increasingly skillful. Besides, it is worth noting that the connections with other organizations are made by these peripheral agents (another important point stressed by Lave and Wenger [1991]. One is thus facing a community of practice.

Articulations between the two observed structures

The LAB then exhibits two internal groups that can be labeled epistemic community and community of practice. The organizing (in a weickian sense [Weick, 1969]) of the LAB constantly intertwines these two communities. One might advance that LAB’s performance in terms of success of experiences, patents and publications depends on the relationships between these two communities. In this sub-section, we propound that these links are established through objects and people.

Objects

Specific objects, in particular lab books, make the two communities interconnect. Lab books correspond to the written traces that agents keep of their experiments. Technicians are the ones who write the minutiae of experiments. They detail preparation procedures, used materials, followed steps, as well as the results of the experiments (such as failure for lack of accurate observations, extreme results, expected changes). They advance in the explanation of these results.

> Claire: “Ah, the lab book: [I am noting things] all the time. I literally fill it every day. Every time I am taking part in an experiment I fill it. I write everything. I write as much as I can every time I am on the work surface. For instance, regarding sequencing, I got to the volume 12 or 13, to my remembrance. (…) ”

These lab books keep the memory of experiments. Technicians fill it with the details of experiments while scientists refer to them when something is not going well and / or to advance on a project.

> André: “The aim of the lab book is to keep trace of the making of a technique, to make it evolve, to note what is working and what is not working. It also helps to understand why some things used to work and do not any more.”

The lab book plays the role of a boundary object between scientists and technicians. Boundary objects are flexible, abstract, polyvalent and standardized enough so that different social worlds can use them and communicate through their usages [Star and Griesemer, 1989]. In the LAB case, the lab book transits from technicians to scientists. In this paper, we go further by advancing that lab books serve as links between the community of practice and the epistemic community. The lab book represents a written memory of the actual practice of scientific experiments. In this regard, it is a central part of the joint ‘repositories’ that characterize the organization of communities of practice, according to [Wenger, 1998]. At the same time, the lab book constitutes a key step to the advancement of scientific programs. Scientists refer the details of experiments to elaborate their proofs and test effects. Uses of the lab book constitute a central intermediate step to the achievement of the central activity of members of epistemic community: the construction of knowledge. Members who are core to the community of practice constitute the lab book, which in turn contributes to the re-foundation of the epistemic community.

An intriguing aspect is that the ones who are in charge of the constitution of the lab book constitute it with their identity of member of a community of practice. We saw previously that making knowledge more explicit is much more a defining feature of epistemic communities than of communities of practice. The writing of the lab book by members of the community of practice then contributes to the interrelation with the epistemic community by transforming the knowing of communities of practice into knowledge to be referred to by the epistemic community.

People

People also relate the two communities first because they play with their simultaneous memberships to them. This relation between community of practice and epistemic community through specific persons is exemplified by Frédéric, the new doctoral student. Frédéric’s practices exhibit his two simultaneous but distinct memberships to the community of practice and to the epistemic community. Frédéric plays with his identities in the laboratory and relates to them differently according to the realm of work that is involved. When realizing his own lab book, Frédéric emphasizes the details of experiences. Afterwards, Frédéric goes back to his lab book to advance on his research project. He does not relate to the same persons to help him constitute or analyze his lab book. When he writes it, he refers to Philippe, the technician at the core of the community of practice. When he examines it, he asks Patrick, his scientific referent, for advice.

Second, at a more collective level, key individuals ensure that the two communities interconnect and contribute to the accomplishment of the overall objective of the entity. The long-lasting relationship between Philippe, who appears as the main referent in the community of practice, and André, head of the center and chief scientist of the LAB plays such a role.

The relationship between these two boundary spanners makes the two communities interconnect. This example nevertheless markedly differs from more customary examples of boundary spanners [Ancona and Caldwell, 1992; Burt, 2000]. Interface persons, usually, are individuals who belong to two social worlds simultaneously and make them communicate through their unique double memberships. Moreover, they lie at the periphery of these two social worlds in order to be acquainted at a minimum to the two cultures. In the LAB case study, on the other hand, Philippe and André occupy central positions in the two communities. Philippe is at the heart of the community of practice, showing his experience and giving advice to technicians and scientists. Philippe is also integrated to the epistemic community thanks to his acquaintance with André. André is not peripheral to the community of practice either. Members of the COP constantly refer to him. They direct many of their messages to him (cf. network). At the same time, André is the most central individual in the epistemic community. His relationships in this community are more bilateral. Both André and Philippe then appear as core individuals in the two communities.

In a more dynamic perspective, Philippe’s situation and competences evolved as well as his relationship with André. Eighteen years ago, he was exclusively a technician. However, three years ago he resumed his formal training and passed a master degree that allow him to enter a doctoral program, if he wanted to.

This master degree makes Philippe gain the same kind of knowledge as LAB’s scientists. His individual trajectory makes him gradually become a key member of the epistemic community (by respecting its formal rules of entry, getting to know its explicit knowledge and taking part in specific scientific projects) while remaining a central member of the community of practice.

Conclusion

This study grounds empirically the distinction between two types of community, communities of practice and epistemic community. Communities of practice are engaged in the daily activities of the organization and oriented toward the perpetual enhancement of individuals' skills in achieving these activities (the conduct of experiment in our case). In this case, knowledge creation is a means to gain efficiency in the practice. Epistemic communities, by contrast, focus explicitly on the creation of new knowledge. This generation of new peaces of knowledge is an end for epistemic communities. This difference in the objectives yields differences in the social norms adopted and in the social structure emerging in each community.

These two social structures are connected one to the other through two important means: boundary objects and boundary spanners. These specific objects and individuals allow a smooth articulation of the two types of communities and hence of the different types of knowledge necessary to the achievement of the organization's objectives. In this respect, boundary objects and boundary spanners realize the necessary combination of the different learning processes taking place within the laboratory. From a managerial standpoint, this implies that one must seek a balance and harmonious relationships between the different communities populating the organization in order to reach a good organizational efficiency.

However, this work present several limitations. First of all, our empirical study only deals with one case. It thus makes it difficult to draw robust implications regarding communities management. There is clearly a need for further empirical research on a broader scale. Moreover, our analysis remains essentially static. We did not explore the path of evolution of the various communities, their possible segmentation, mixing, re-organizing, etc., while these questions are of up most interest for instance in the study of free software development. All these limits are indicative of the work that remains to be done in the exploration of communities and their impacts on the functioning of organizations.

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