PROPOSAL OF A FRAMEWORK FOR CHARACTERIZING VIRTUAL COLLECTIVES IN THE ENGINEERING DESIGN FIELD

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Abstract

To manage global innovation firms organize their global R&D footprint all around the world to optimize knowledge access. This has lead to distributed design teams around the world. It is the case of Alstom Renewable Hydro Power where this research has been conducted. Hydro business designs turbines and generators that entails different types of objectives that can be: standardization of engineering processes, development of common design guides for engineering tools, harmonization of quality sheets and troubleshooting procedures. Hydro has entrusted these objectives to distributed engineering collectives. Most of these collectives are supported by ICT tools and qualified as design communities, virtual teams and networks of experts inside the company. Our research aims to clearly define the design choice of a virtual engineering collective type for a specific objective related to knowledge creation or knowledge exchange. This paper's objectives are to define, to characterize and to differentiate every virtual engineering collective. Our finding is a virtual collective framework that is composed of 7 critical differentiator factors that will characterize these virtual collectives.

Keywords: Design management, Collaborative design, virtual engineering collectives, Knowledge management

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1   INTRODUCTION

Globalization has changed the organization of engineering activities in the product design and development lifecycle. To manage global innovation firms organize their global R&D footprint all around the world to optimize knowledge access. Doz and Wilson (2012) recommend being present in knowledge "hotspot" where complex knowledge is highly context dependent and thus hardly transferable. On the other hand they consider explicit knowledge codified as more easily shared and transferable via common language and processes. This has lead to design teams distributed all around the world. It is the case of Alstom Renewable Hydro Power where this research has been conducted. The business Hydro designs different operating ranges of turbines / generators on an international market for hydraulic power generation. The organization of the Global Engineering and Manufacturing (GEM) function has sequenced design activity between upstream activities to provide technologies, methods, tools and downstream activities, mandated to develop and adapt these methods to the context of local projects. The GEM aims to increase the engineering performance in regions (India, China, Brazil, Canada, Russia and Europe) and to ameliorate the technical collaboration between them. This entails different types of objectives that can be: standardization of engineering processes, development of common design guides for engineering tools (CAD, CAM& CAE), harmonization of quality sheets and troubleshooting procedures and compliance with international material datasheets. Hydro has entrusted these objectives to distributed engineering collectives in a way to have from one side localized resources closer to customers, and from another side product experts gathered in centers of expertise. Most of these collectives are supported by ICT tools and qualified as communities or virtual teams inside the company. However these virtual engineering collectives may take several forms and manifest into multidisciplinary teams, design communities, or networks of experts. Often, these virtual collectives tend to be cross-functional, span organizational boundaries, have multiple cultural values and rely on Information and Communication Technology (ICT). These virtual collectives are of importance since they "allow organizations to improve efficiency and productivity, procure expert knowledge from internal and external sources, and transfer best practice information" (Huber, 1990). They extend their local experiences by integrating similar or complementary virtual collectives. They offer organizations a global pool of expertise to compose tailored virtual collective that rapidly encounter an emerging organizational need.

This paper objective is to be able to clearly define the design choice of a virtual collective type for a specific objective related to knowledge creation or knowledge exchange. Our research questions are: 1) what define and what are the characteristics of every virtual collective: virtual teams, virtual communities (VCoP and VCoI) and networks for learning? 2) What are the similarities and the differences among these virtual collectives in respect to a specific knowledge objective?

We conducted a literature review. As result we found out that the literature around these concepts is fragmented and doesn't present a comprehensive framework that characterizes and distinguishes these virtual collectives in relation to a knowledge management objective. In order to attain this objective that is to define a comprehensive framework, the paper is composed of three sections: the first one will present the definitions and the characteristics of virtual teams, virtual communities (VCoP, VCoI), and networks for learning. In the second section we will propose a virtual collective framework that is composed of 7 critical differentiator factors that will explore the similarities and the differences among these virtual collectives. The third section will be the application of the virtual collective framework to our 4 types of the virtual collectives. We will conclude in the final section on our findings and we will propose some insights of future works. We will question the possibility to define strategies to transition from one virtual collective to another, thus forming a virtual continuum of these informal social groups.

2   QUALIFYING VIRTUAL COLLECTIVES FROM LITERATURE

These virtual collectives are essentially characterized as "informal social group" (Bettoni et al., 2007) but these virtual collectives become more and more important within companies. In informal social groups, the members have informal discussions around a common interest and are bounded by a shared goal rather than the organizational hierarchy. The informal human interactions and relationships are of great importance for knowledge management (Wenger et al. 2002). Many forms of these virtual collectives had been introduced to the business environment and through a literature review we could identify a list of these informal social groups. We are interested in some of them

which are referring to knowledge management: Virtual Teams (VT), Virtual Communities of Practice (VCoP), Virtual Communities of Interest (VCoI), and Networks for Learning (NoL).

2.1 Virtual teams

Virtual Teams is one of the eminent forms that had been adopted by organizations. They are playing an increasingly important role in international business by offering organizations the opportunity for reaching beyond traditional boundaries (Pauleen & Yoong 2001). The scientific as well as the professional literature had addressed thoroughly the virtual teams concepts and it is in early 1990 that the first notion of virtual teams has appeared (Lipnack & Stamps 1997; Maznevski & Chudoba 2000; Lurey & Raisinghani 2001; Cascio & Shurygailo 2003; Powell et al. 2004; Staples & Zhao 2006; Anderson et al. 2007; Huber 1990). These authors has agreed to some extent that virtual teams are teams with geographically distributed members, cross time and organization boundaries, are culturally diverse, utilize computer mediated communication to perform non-routine but interrelated tasks and are united around a common goal. Lipnack & Stamps (1997) defined VT as "groups that work across space, time and organizational boundaries with links strengthened by webs of communication technologies". Lurey & Raisinghani (2001) defined virtual teams as "groups of people who work together although they are often dispersed across space, time, and/or organizational boundaries". Powell et al. (2004) defined virtual teams as "groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks''. The following authors Bal and Teo, (2000), Gassmann and von Zedtwitz (2003), Paul et al. (2005), Wong and Burton (2000) included in their definitions the temporary aspect in the virtual team lifetime or for some team members. As summary, a team will become virtual if it meets four main common criteria: 1) geographically dispersed (and over different time zones) 2) driven by common purpose 3) enabled by communication technologies 4) involved in cross-boundary collaboration. In their review of literature, Ebrahim highlight others characteristics of virtual teams: the team is small, non-permanent. Members are mainly knowledge workers, and teams can cross companies' boundaries (Ebrahim et al., 2009).

2.2 Virtual Communities of Practice (VCoP)

Another noticeable entity that comes out from the knowledge management literature is Virtual Communities of Practice (VCoP), which is gaining reputation in the business context. Latest reports show that VCoP are being considered as strategic assets for multinational corporations to bring people together and to share knowledge in multisite working environment (Davenport, 1996; Cohen & Prusak, 1996; Ellis, 2001; Haimila, 2001) as cited by (Ardichvili et al. 2002). Lave and Wenger (1991) first introduced the term community of practice (CoP). Lave and Wenger (1991) used it in their exploration of situated learning. It is through the process of sharing information and experiences with the group that the members learn from each other, and have an opportunity to develop themselves personally and professionally (Lave and Wenger, 1991). Wenger (1999) understands a CoP as a special type of community where practice is a source of the coherence to pursue a joint enterprise. In a community of practice (CoP) "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis". CoP is seen as a strategic asset to create and share organizational knowledge. Using information and communication technology (ICT) such as Internet to support their ongoing interactions, CoPs are going virtual. They form a "virtual community of practice" (VCoP) (Dubé et al., 2006; Fraslin and Blanco, 2013; Fraslin et al., 2011) when they collaborate online, such as within discussion boards and newsgroups. VCoPs frees their members from constraints of time and space.

2.3 Virtual communities of interest (VCoI)

Additional interesting type of communities that facilitate the exchange of knowledge is virtual communities of interest (VCoI)(Wenger et al. 2002). Basically, a community of interest (CoI) is a group of people who share a common interest and who want access to community information (Wenger et al., 2002). Relying on information and communication technology, we define virtual community of interest as a social group of people who share a common interest and communicate through social technology services.

2.4 Networks of practice & Networks for Learning

Larger forms to create and exchange knowledge are networks of practice (NoP) and networks for learning (NoL). They are considered as knowledge networking infrastructure that facilitate the knowledge management activities across temporal and spatial boundaries (Hustad, 2010).

The concept of networking for learning was coined to agricultural knowledge systems (Engel, 1997) and soft-system analysis (Checkland and Scholes, 1999). The Resource Centre for Development of the Skat Foundation (2004) as cited by Cummings and Zee (2005) had defined the term "network" as a description for institutionalized partnerships between institutions or organizations and may even take the form of a legal entity. Giving this definition, networking is about organizations, institutions and individual actors joining forces around a common concern. Most often, it is about building relationships with other independent actors to share knowledge, goods and experiences and to learn from each other with a common goal in mind (Padron 1991; Plucknett 1990; Engel 1993) as cited by Cummings and Zee (2005). Brown & Duguid (2001) coined the phrase "networks of practice" (NoPs) to describe one type of networking. NoPs are composed of people who are geographically separate, share similar practices but may not necessarily have regular meetings or even have to know each other's.

When it comes to social learning theory, the literature around the virtual collective forms e.g.: virtual teams, virtual communities of practice, virtual communities of interest and networks for learning don't clearly differentiate the boundaries between every type. Hence, a framework is required to clearly define the similarities and the differences between these types.

3 VIRTUAL COLLECTIVES FRAMEWORK: DESIGN

In a previous quest to find a framework that differentiates the virtual engineering collective, we conducted a literature review to survey the current frameworks or models. We searched in knowledge management journals, engineering design journals, and organizational sciences in order to fulfil our requirements. The keywords that directed our literature review were: group's dynamics, virtual teams effectiveness, communities' performance, geographically distributed teams, and networks of experts. We find out models that describe group behaviours, interactions and dynamics. In addition, we got frameworks that describe the characteristics of virtual teams and virtual communities separately. In these frameworks they studied which characteristics impacted the team's effectiveness or the community success. The main results were obtained from the management sciences literature and few were found in the engineering design literature. Nonetheless, we are interested in dominant characteristics that can clearly define the frontiers of every virtual collective. So we started to list all possible characteristics from every model or framework. Then we clustered this exhaustive list of characteristics into groups with similar semantic. As result we obtained 10 families of characteristics where each contains a set of factors that characterizes any collective. The 10 families of characteristics are: collective's task design, collective's technology, collective's strategic directives, collective's structure, collective's processes, collective's members interaction, collective's health, collective's performance and collective's members satisfaction. Having in mind that we are searching for characteristics that can clearly differentiate the collectives, we opted out 7 and we identified them as critical differentiator factors (CDFs) and they are as follows: Purpose, membership, bonding, diversity, structure, life span and processes.

- Purpose: what is the virtual collective for and if there are any capabilities that are produced?
- Membership: who belongs and what are the conditions of belonging to the virtual collective?
- Bonding: what ties the members together and why they collaborate together?
- Diversity: do they have different cultures, values, profiles and expertise?
- Structure: how the virtual collective is organized and connected?
- Life Span: what is the virtual collective duration and when does it disband or evolve?
- Processes: how the members work together or interact in the virtual collective?

Table 1 shows the literature references for these CDFs. We suppose that with these CDFs, we can eventually draw a virtual frontier between the virtual teams, virtual communities and networks for learning.

Table 1. References for the critical differentiator factors

	Virtual Teams	Virtual Community of Interest	Virtual Community of Practice	Networks for learning
Purpose	(Huber, 1990; Lipnack and Stamps, 1997; Lurey and Raisinghani, 2001)	(Fischer 2001; Wenger et al. 2002)	(Wenger, 1999; Wenger et al., 2002)	(Engel & Alders 1993; Engel 1997; Checkland & Scholes 1999)
Membership	(Lipnack and Stamps, 2000; Sadri and Tran, 2002)	(Nousala and Hall, 2008; Wenger et al., 2002)	(Murillo 2011; Lave & Wenger 1991)	(Engel, 1997)
Bonding	(Granovetter, 1973; McGrath, 1984)	(Andriessen, 2006; Mcdermott, 1999)	(Murillo, 2011; Wenger et al., 2002)	(Engel and Alders, 1993)
Diversity	(Cohen and Bailey, 1997; Lipnack and Stamps, 2000)	(Fischer and Ostwald, 2005)	(Dubé et al., 2006; Wenger et al., 2002)	(Engel et al., 2003)
Structure	(Jarvenpaa & Leidner 1999; Wong & Burton 2000)	(Fischer, 1995; Wenger et al., 2002)	(Leavitt and Paige, 2001; Wenger et al., 2002)	(Engel & Alders 1993; Hustad 2010)
Life Span	(Bell 2002; Bal & Teo 2000; Paul et al. 2005)	(Fischer, 2001)	(Dubé et al., 2006; Wenger et al., 2002)	(Engel and Alders, 1993; Engel, 1997)
Processes	(Bell, 2002; Joinson, 2002)	(Fischer, 2001; Wenger et al., 2002)	(Hildreth & Kimble 2004; Lave & Wenger 1991)	(Cummings and Zee, 2005)

4 VIRTUAL COLLECTIVES FRAMEWORK: APPLICATION

In the business context, virtual teams are defined to run and accomplish projects. Apparently they are virtual project teams and they are initiated for specific purposes. Lipnack & Stamps (1997) state that virtual project teams are like any team whose tasks are interdependent but guided by specific purpose. This purpose can involve multiple departments to implement a specific management system, to study technical proposals or to improve existing processes. It appears also essential that the common purpose is supported through visual communication like team charter (Joinson 2002). Team members are selected with different profiles from different functional units and are bonded together to execute the project's deliverables and to meet the project's milestones. Cohen & Bailey (1997) reflect that a multitude of knowledge and expertise should be applied in project teams. Memberships in VTs tend to be temporal and in function of the project planning. For example, a quality engineer may be called to inspect a welded structure and if it meets the quality sheet criteria's. VT boundaries are more permeable than traditional project teams where the expertise may be located anywhere in a multi-site company. VT context is one of the characteristics introduced by Wong & burton (2000) to qualify virtual teams highlights the dynamics of teams that can be quickly setup to face new problem or market opportunity involving dispersed expertise in a non-routine task. This point is also present in the following authors Bal & Teo (2000), Paul et al. (2005), Gassmann & von Zedtwitz (2003)

definitions that include the temporary aspect in the virtual team lifetime or for some team members. VTs form and disband as organizational goals change (Jarvenpaa & Leidner 1999). Bell (2002) suggests also that the lifecycles of virtual teams are largely determined by the nature of the tasks these teams perform. If turnover is high, time and effort will be spent orientating new members on contrary to teams whose membership is stable. Team history can be an important element for the team performance. The composition dimension is the second characteristic from Wong and burton (2000). The composition characterizes the heterogeneity of members that can be identified by organizational belonging, cultural backgrounds, languages, expertise differences etc. The third characteristic of Wong and burton (2000) is the structure of a group that describes the nature of links between the team members referred as patterns of relationships among individuals in work groups by McGrath (1984). Virtual teams are mainly lateral and weak relationships. Lateral links are supposed to facilitate coordination and information flow. In virtual teams, the relationships between members tend to be lateral but weak due to the physical dispersion and the nature of the work that virtual team members are typically engaged in. Lateral communication ties often connect VT members. Based on Granovetter's weak tie model (1973)(combination of the amount of time, emotional intensity, intimacy, and reciprocal services), Wong & Burton (2000) found that ties between virtual team members are lateral and weak. Structural dynamism within the team may be controlled by: setting up firm rules for communication to avoid loss of knowledge (Joinson, 2002); encouraging mentoring relationships between members, as this allows members to adapt quickly and feel part of the team (Sadri & Tran 2002); and by encouraging knowledge transfer by having regular meetings. As tasks become more complex, integration and coordination among members requires formal mechanisms. Therefore it becomes more difficult to recruit new team members. Teamwork, communication and feedback processes become more important when members' roles are interrelated and coordination is required as stated by Bell (2002).

The second virtual collective is VCOP where members participate in communal learning as they are situated in the community. Lave and Wenger (1991) saw the acquisition of knowledge as a social process, where a newcomer to the community advances in his apprenticeship by increasing his participation and getting acknowledged. The process by which a newcomer learns by being situated in the group was central to their notion of a CoP. They termed this process as legitimate peripheral participation (LPP). In such a community, a newcomer learns from seniors who share their experiences in story telling fashion. A newcomer is a debutant practitioner. The opportunity is given to him to participate in certain tasks in relation with the community's practices. Over time the newcomer moves from peripheral to full participation. Lave and Wenger (1991) regard a Community of Practice as "an intrinsic condition for the existence of knowledge". For Lave and Wenger (1991), the participation in the community is crucial for developing the practice. Being a member of a VCoP implied participation in the community's activities where members have a common understanding about their domain of knowledge. This domain creates the ties between the members, forms their joint enterprise and constitutes their unified identity (Wenger et al., 2002). Members interact together through mutual engagement as these interactions impact directly their daily work. Unlike face-to-face communications, Internet based communication enlarge the scope of mutual engagement and expand the possibilities of interactions (Murillo, 2011). A set of communal resources result from the mutual engagement. Usually, these resources are stored in a shared repertoire such as practices, artefacts, routines and symbols. In particular, artefacts play an important role of sustaining the participation in the community. They act as knowledge objects to symbolize implicit knowledge in the process of creating and sharing knowledge. Hildreth and Kimble (2004) observe that the process of creating the artefact and mid-term face-to-face meetings are influential in maintaining the relationships that allow a CoP to function successfully in a virtual environment. Thus, paradoxically, it appears that one of the keys to a successful VCoP is an occasional, non-virtual, face-to-face meeting. Wenger (1999) also identified two key processes to belong to CoP: participation and reification. He described participation as: "... the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises" (Wenger, 1999) and reification as: "... the process of giving form to our experience by producing objects that congeal this experience into thingness" (Wenger, 1999). Membership commonly crosses boundaries across work groups, organizational units and even organizations (Wenger and Synder, 2000). Informal discussion tends to increase the level of trust between members, which has positive consequences on sharing knowledge. While members dispersion and boundary crossing hinders the informal communication, the level of trust between

members is affected (Wenger et al., 2002). A VCoP may have permanent members (i.e., a stable membership), but can also have changing membership, ranging from moderately stable to fluid. Members' enrollment can take many forms, from voluntary to strongly encouraged, to compulsory (Leavitt and Paige, 2001). VCoPs life span varies widely (Wenger et al., 2002). While it may initially be indeterminate, a VCoP can be assembled on a temporary basis to accomplish a specific purpose (e.g., a response to an ad hoc environmental change), but is usually created on a permanent basis with no definite time frame, as an on-going mechanism to develop practices. VCoPs are often created to break organizational silos and promote collaboration, learning, and knowledge sharing (Dubé et al., 2006).

On contrary to VCoP, the purpose of a VCoI is less specific. It consists of being informed, discussing and sharing understanding about a particular topic, problem or concern that interests community members. VCoIs are usually temporary (Fischer, 2001) because they arise together in the context of a specific common interest and when this interest becomes less important, the community tend to dissolve itself. VCoI membership is usually open. Everybody who is interested in the information that is managed by the community can access it (Wenger et al., 2002). Individuals are involved in the community in an ad-hoc manner (Nousala and Hall, 2008), when they want to exchange questions and solutions about the common interest (Mcdermott, 1999). This exchange among community members produces mutual needs that are the motivation to hold them together (Wenger and Synder, 2000). VCoI members do not have a strong identity because relationships are always shifting and changing (Andriessen, 2006). A community of interest is then a different structure than a community of practice. A VCoI is characterized by a shared common interest and its purpose is that everybody interested can access and exchange information. VCoI members hold together because they want to be informed. VCoI members are bonded together just because they want access to information and participation about a collective interest or concern with the resolution of a particular problem. So whoever is interested in the common shared topic or concern of the community can join. This structure could bring together stakeholders from different domains and even CoPs (Fischer, 1995), collecting different perspectives and enhancing diversity. VCoI structure is dynamic and based just on participation. Because VCoIs are structures formed by stakeholders from multiples domains, members are considered both experts and novices at the same time: they are experts when they communicate their knowledge to others, and they are novices when they learn from others who are experts in domains outside of their own knowledge (Fischer and Ostwald, 2005). VCoI does not have any regulated function. There is no specific way to build either a collaborative relationship or negotiated rules. As a result, it is a more suitable structure to encourage creativity and innovation.

In networks for learning, the network partners share common objectives but they are still autonomous and contribute their resources, their skills and their assets voluntarily. The network partners have a set of common activities and regular events. Participants must commit act upon the network priorities. They must be motivated by self-interest because networking is closely related their daily work and a potential added value for their careers. Networks for learning often goes through a process of institutionalization (Wielinga 2001) as cited by Cummings and Zee (2005) . Each network develops its structure as a combination of agreements, procedures, and culture. It is important for a networking process not to lose its flexibility – which can happen when procedures and controls are becoming predominant and vitality, enthusiasm and satisfaction flow away (Cummings and Zee, 2005). Engel (1997) argues that social learning is a complex activity that manifests itself in a relatively stable change in person's behaviour or a group of persons. Engel et al. (2003) argues that actors in networking for learning invest in new ways of communication to organize themselves, to learn, to network, to cooperate and to collaborate for innovation - the output of the social learning process. Through these ways of communication, actors leverage their capacity to learn and implement new practices faster. It's through these communications those actors and stakeholders become practitioners. These practitioners are at the core of networking for learning: as active, as knowledgeable participants who can take decisions and resolve conflicts. The practitioners interact with each other's through interfaces and shared boundaries. They are linked together through knowledge bonds for joint learning and they continuously interchange their experience. These links allow the exchange of intangible assets such as information, expertise and techniques, tangible assets such as logistics, financial resources and other assets, such as power, status, or even good intentions. Practitioners' participation also involves their contribution to the decision making process that will impact their daily activities and it will be conducted. Strongly related to participation is the notion of volition, as described by

Engel and Alders (1993). Volition emphasizes sense making to create comprehension, purpose and commitment to decisions that have been taken. Volition should also be fluid: an informed and thoughtful volition, which is always subject to evaluation and re-formulation. Volition requires mutual engagement from all actors to make it possible.

As summary, the application of the virtual framework to the 4 virtual collectives types is shown in Figure 1.
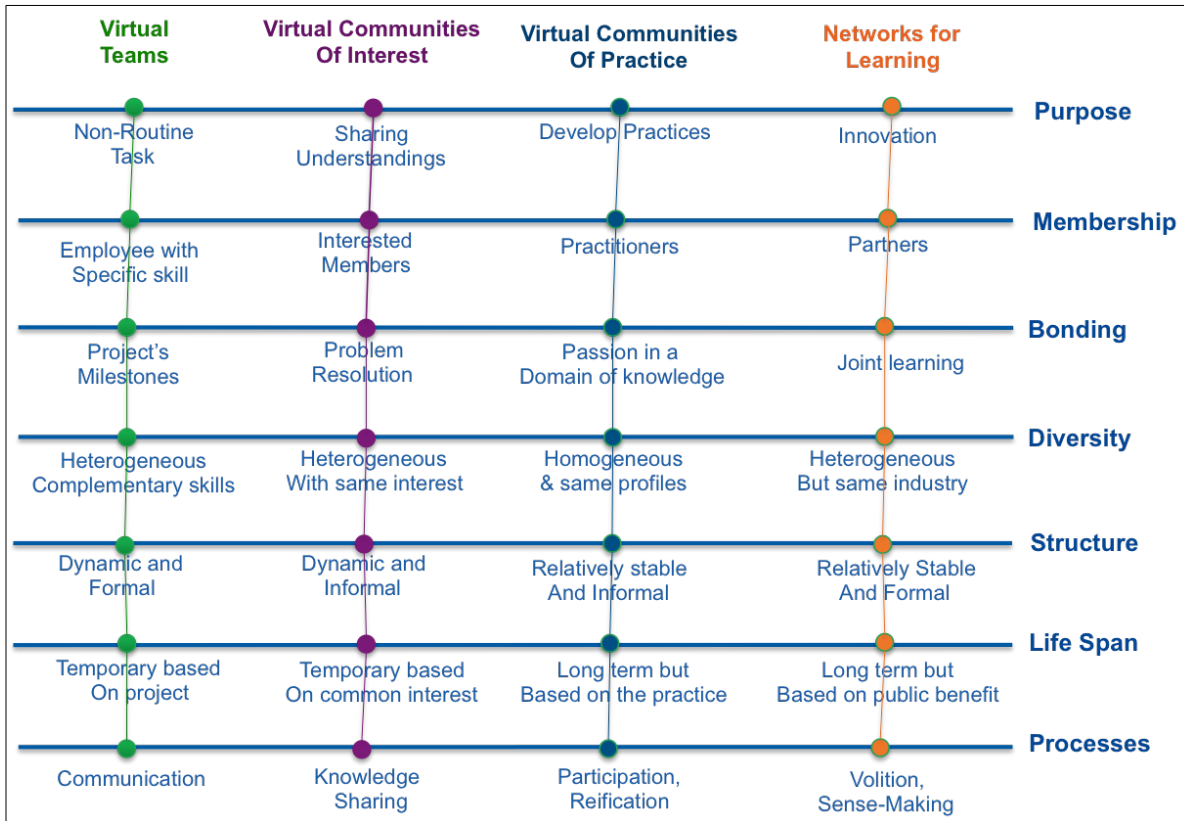

Figure 1. Application of the virtual collectives framework

5 DISCUSSIONS AND PERSPECTIVES

The literature is rich and diversified about the informal social groups. But there were no clear boundaries between the virtual teams, virtual communities of practice, virtual communities of interest and networks for learning. Through previous studies, we could identify dominant characteristics that can help us to undoubtedly differentiate between the 4 virtual collective types. We defined these dominant characteristics as critical differentiator factors CDFs, which in their turn will support our virtual collective framework. One limitation to this framework is how to guarantee the pertinence of these CDFs and their applicability to new types of virtual collectives (i.e.: workgroups, parallel teams, engineering clubs…)? Therefore, will these CDFs be able to distinguish future types of virtual engineering collectives? Another limitation may question the completeness of the defined differentiator factors set. One potential differentiator factor will be the leadership style. A consensual, participative leadership style may fit the VCoP and the VCoI while a more directive leadership style may be suitable to VTs and networks for learning. This reflection about the leadership style will investigate from one hand the institutionalized structures vs. the informal structures and from the other hand innovation objectives vs. specific operational objectives. However with this framework we tried to understand the differences between the 4 selected virtual collectives and consequently to answer our initial question which virtual engineering collective type is the most appropriate to realize a given knowledge related objective? The next step is to expand this virtual collective framework and try to include the managerial guidelines and best practices to design and implement a given virtual collective. Moreover, what is the best strategy to form a virtual team? Would an effective virtual team

be formed from virtual communities of practice or virtual communities of interest? If so, how to leverage the history and the previous experience between the community members to form the virtual team? And what are the mind-sets changes to perform while transitioning from a community-working mode to a team-working mode? Another question emerges at the end of the virtual lifecycle: how the team members will capitalize back their acquired experience due to project completion and transform it into formal knowledge with their community peers? We will also be studying the performance of these virtual engineering collectives. Does performance is considered as an end or a mean? Does it mean productivity or establishing relationships between the members? We will investigate what will make them effective and performing. In particular, what are the characteristics of a successful virtual team, an effective virtual community, or a high quality network for learning? Finally we will try to help the practitioners by identifying a set of critical success factors to implement and evolve VTs, VCoPs, VCoI, and NoL through their corresponding lifecycles. The next research activities will continue in the global engineering and manufacturing function at Alstom Renewable Power – Hydro. The GEM have 12 engineering communities scattered around the world and are classified into 3 main families: those who design the product are the tools communities, those who manufacture the product are the industrial communities and those who define the technical purchase specifications with the suppliers are the standardization communities. These engineering communities will be of great importance for our next research activities. We will try to investigate in depth these engineering communities in order to respond to our perspectives. At the end, we will try also to transpose the virtual collectives framework to other industries with different profiles and different expertise.

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