Ba evolution. Virtual spaces for inter-organizational knowledge creation

Journal:	*Journal of Knowledge Management*
Manuscript ID	JKM-09-2015-0342
Manuscript Type:	Research Paper
Keywords:	Knowledge creation, Knowledge management, Organizational innovation, Knowledge Management Systems

1. INTRODUCTION

Nonaka's modern conception of knowledge management has stressed the subjective nature and the relativity of knowledge concept. It depends on individuals that hold and create them, but also on contexts and spaces that hold and frame it (Nonaka & Toyama, 2005; Polanyi, 1967).
Particularly, Nonaka in his numerous works elaborated the SECI (Socialization, Externalization, Combination, Internalization) model of knowledge creation at the level of analysis of a single organization, also providing a categorization of organizational spaces that can host each of the phases of the knowledge creation process (Nonaka & Konno, 2005).

Taking Nonaka's SECI Model as main reference, this paper aims at reflecting about the contemporary evolution of places for knowledge creation, that in this theoretical framework are defined *ba*.

Indeed, looking at current scenario, it appears inevitable taking the cue of Nonaka himself to enlarge the knowledge spiral to inter-organizational epistemological level. To this aim, information technology tools and virtual communities can build the bridge to establish effective interactions to exchange knowledge (Panahi et al., 2013), and congruently they can make ba change and evolve (Hessman, 2013).

Nevertheless, the main problem with this kind of solutions is the issues linked to Socialization phase as long as tacit knowledge and contextual knowledge sharing seems to be possible just through vis-à-vis interactions (Tee & Karney,2010; Saenz et al., 2012). Moreover, also inter-organizational knowledge transfer *per se* seems to be problematic, involving cultural issues and trust need (Tuomi, 1999).
This paper attempts to fill this gap and answer these interrogatives in organizational and knowledge management literature. To this purpose, it takes also into account a European Research project, called BIVEE - Business Innovation in Virtual Enterprise Environments –FP7 project, subprogramme area: FoF-ICT-2011.7.3 (Virtual Factories and enterprises), that was rated with "Excellence" by the European Union (http://cordis.europa.eu/project/rcn/100275_en.html).
Adopting a Participatory Action Research approach (see for example: Ragsdell, 2009; Coughlan & Coghlan, 2002; Brydon-Miller et al., 2003; Gummesson, 2000) the project gave birth to a methodology to develop virtual platforms implementing Open Innovation paradigm (Chesbrough, 2006; 2007) and building up a cyber-physical system. Particularly, it broke the innovation process into the main waves that are present in any innovation processes, from idea generation to product engineering, and it applied SECI model to each of them. Thus, the aim of the paper is to give some insights to make organizational practice in knowledge and innovation management more effective and at the same time to produce a theoretical generalization to advance SECI knowledge creation theoretical model.
Particularly, through case study, the paper comes to show an evolution of SECI model for knowledge creation at an inter-organizational level. Moreover, through a learning history showing the main steps of innovation process, it describes how all the phases of SECI process, even Socialization one, can take place or be supported in virtual spaces.

The paper presents in the first paragraph a theoretical and multidisciplinary framework. It then deals with methodological and approach issues, presenting the Bivee project and contextualizing SECI spiral model and Open Innovation approach within the platform design.
After that, it presents a real learning history to show and explain the functioning of the platform model, structuring it accordingly to SECI model phases.
Eventually, it draws and discusses some theoretical conclusions.

2. THEORETICAL FRAMEWORK

Looking after the original concept by Japanese philosopher Nishida (Nonaka & Toyama, 2005: 428), *ba* has to be considered as a shared space representing a foundation for knowledge creation, and thus a platform for advancing individual and organizational knowledge (Nonaka & Konno, 2005) through interaction. Then, what represents the essence of *ba* is the contexts and the meanings created and shared through interactions happening at a specific time and space, rather than the space itself. As a result, managing organizational knowledge means managing the context and conditions by which knowledge can be created, shared, and implemented (Wei Choo & Correa Drummond de Alvarenga Neto, 2010).In considering the ontological and the epistemological dimensions of knowledge creation processes, Nonaka and Konno (2005) indentified four different stages (Socialization-Externalization-Combination-Internalization) to build up a spiral model. Also, they defined a coherent set of *ba* with different characteristics suitable to host and better support the processes and dynamics of knowledge that take place during the different phases.

- **Originating *ba*** is a dimension where individuals share emotions and experiences sympathizing and empathizing with others, removing any psychological barriers. That's the primary *ba* that kicks off the knowledge-creation process with the Socialization phase.
- **Interacting *ba*** is an environment that is constructed more consciously picking people with specific knowledge and capabilities to integrate. Here, during the Externalization process, tacit knowledge is made explicit through dialogue and metaphorical language (Nonaka & Nishiguchi, 2001: 20).
- **Cyber *ba*** is a virtual world to interact in and combine explicit pieces of knowledge. The Combination phase taking place in this space, is enhanced by information technology that allows the use of on-line networks, group-ware, documentations, and database.
- **Exercising *ba*** supports the conversion of explicit to tacit knowledge. This phase is called Internalization and consists in the continuous implementation of explicit knowledge in real life or simulated applications.

This *ba* categorization appears to be functional and necessary to successfully support knowledge creation in its different phases. However it is important to know organization's *ba* does not consist just in the accumulation of information or documents, rather it has to be interpreted as a continuous dynamic cycle of converting tacit into explicit knowledge and back.

Table 1 Categorization of *ba* within SECI model.

The choice to focus the literature review on Nonaka's original papers on *ba* is an aware one. Indeed, despite the possible limitations of considering just one author's work, the choice was aimed at focusing on the original sources.

Now, what jumps to the eyes in this model overview, is the huge importance explicitly accorded to physical proximity and vis-à-vis interaction. They represent the key to conversion and transfer of tacit knowledge and thus the trigger for the whole knowledge creation process. Indeed, according to this model, new knowledge always begins with individual sharing tacit knowledge directly to another (Nonaka, 1991). On the contrary, virtual spaces, namely cyber *ba*, are mostly limited to the combination phase. Here, explicit knowledge is generated and systematized merging information throughout the organization. Obviously, information technology is essential for providing the collaborative environments to support this phase of

SECI model (Nonaka, 1991). Although, virtual spaces and ICT are mainly considered as accessory tools to be used just once implicit knowledge has been converted in explicit knowledge, to merge or store it.

Indeed, Nonaka based his model on Polanyi (1967)'s conception of knowledge considering it as inseparable from individuals and deeply embedded in a specific context. From this perspective, knowledge represents the result of relative and subjective elaborations of objective information and organizational knowledge represent the result of relationships and interactions (Nonaka & Toyama, 2005; Polanyi, 1967).

In these regards, nowadays social media or virtual platforms, ICT devices or applications are able to enhance and support social relations and knowledge sharing or transfer (Panahi et al., 2013; Siebdrat et al. 2009) and, consequently, they could be considered as essential elements to build up a proper space for knowledge creation or innovation. Particularly, taking into account the evolution of organizational space itself, it seems totally appropriate to re-discuss and reconsider the spatial aspects of knowledge-related processes. Contemporary organizations merge physical dimension with the virtual one; work spaces with data flows. They often represent cyber-physical systems, interconnecting webs of information and production (Hessman, 2013).

In this vein, also drawing inspiration from Castells' works on urban space as mirror of social organization, it could be meaningful and valuable moving the reflection to organizational spaces. Being open systems, organizations, as well as cities, can be conceived as made up, at the same time, of flows and places, and of their relationships (Castells, 2005). The interface between electronic communication and physical interaction, the combination of networks and places, shape and deeply transform knowledge creation processes. Particularly, these considerations acquire significance and relevance at inter-organizational epistemological level of knowledge creation. Indeed SECI model was developed from an intra-organizational point of view, while the inter-organizational level of analysis was marginally left as possible and interesting field of future researches, without being analyzed in its dynamics.

Moreover, considering the rise of Open Innovation paradigm (Chesbrough, 2006; 2007) and the constitution of networks and community of people and of organizations in the current scenario, it's evident that knowledge creation processes are strongly influenced and sustained by information technology (see for example Martínez-Torres, 2014; Hüsig, 2011; Tickle, 2011). Consequently, one of the most detailed critiques to SECI model concerns the functioning of the model in cross-cultural organizations. Indeed Tuomi (1999; Šarkiūnaitė & Krikščiūnienė, 2005) outlined how the SECI model was developed from the viewpoint of inner action of one single organization and how culture and language are taken for granted without paying any attention to respective differences. Indeed one of the main unexplored questions is that of the functioning of the model in a network of many different organizations or members of those organizations, where the cross-culturalism can cause problems due also to different kinds of organization cultures (Kostiainen, 2002). That's because knowledge transfer is possible through an interactive mechanism that is based on shared rules, norms, organizations, and procedures (Fong Boh et al., 2013; Siebdrat et al. 2009).

Particularly, the essential precondition for originating *ba* to rise is a strong sense of belonging and a strong commitment of the network members, to make them perceiving tacit knowledge transfer as the core purpose of the network itself. To this end, the trigger for Socialization process is a field to interact and share experiences so that it is possible to deeply understand and empathize with others' *modus cogitandi* and mental models (Takeuchi & Nonaka, 2004).

To this purpose, high-fidelity communication media (McLuhan, 1964; Panahi et al., 2013) are very useful since they are able to send complete messages, convey lots of tacit and contextual components, requiring little extra interpretation. However, Socialization in an online environment is still challenging and,

considering the importance accorded to the Socialization phase, the consensus is that it should always cover a face-to-face component (Siebdrat et al. 2009; Tee & Karney, 2010; Saenz et al., 2012).

Nevertheless, according to the theory of innovative *milieux*, networks should be spread outside the restricted region one belongs to, in order to gain new information, competencies and influences (Kostiainen, 2002). Moving to organizational contexts, the Open Innovation paradigm (Chesbrough, 2006) claimed the importance for an organization to grasp idea intra and *extra moenia* to faster reach markets and their needs and to make their competencies evolve accordingly (Allen, 1984). In this regard, ICT solutions can meet the need for weak ties to expose individuals to new ideas that can trigger new knowledge creation (Alavi & Leidner, 2001).

Nowadays, various communities have already taken advantage of the web to ease communication and information flow inside and outside of the community (see for example Dong, 2014; Tickle, 2011; Battistella, 2013; Balka, 2014; Bugshan, 2015; Siebdrat et al. 2009). However it's evident that cultural barriers to knowledge sharing and transfer cannot be effectively reduced or eliminated just through ICT applications (Panahi et al., 2013; Li, 2010). On the contrary, they could even be emphasized. Moreover, new knowledge creation process and innovation itself depend not just on a free flow of information in general, but on the recombination of non-obvious knowledge to trigger innovative solutions to complex problems. In this view, technology is not irrelevant, but it is insufficient by itself (Hargadon, 1999; 2002; Panahi et al., 2013). Thus, according to Davenport and Prusak it has already been proved that technology can't replace human knowledge or create its equivalent (Davenport & Prusak, 1998: xi). That is to say, human factor is the essential one when it comes to knowledge and knowledge creation processes, in which technology can yet represent a useful tool. Indeed, these features are useful to build virtual groups communities of interest and provide support for creating concrete output, such as information items that can be accessed by the community (Lausen et al., 2005).

In Nonaka's SECI model, ICT is contextualized within cyber *ba*. This *ba* can be considered as a place of monologue, in which new explicit knowledge is combined with existing knowledge. However, considering the flexibility of modern IT, other forms or features of organizational *ba* and the corresponding phases of knowledge creation can be enhanced through several kinds of information systems (Alavi & Leidner, 2001; Lopez-Nicolas & Soto-Acosta, 2010). Especially considering the inter-organizational epistemological level. Nevertheless it is necessary to always have in mind that the Web is not only an interlinked cluster of machines but rather a network of humans negotiating linguistic meanings through machines (Shvaiko et al., 2010).

3. METHODOLOGY

This paper wants to contextualize SECI model within a web platform for Open Innovation, in order to inquire whether and how a knowledge creation circle process can entirely take place within a virtual environment linking several subjects from different organizations and universities.

To this purpose, it takes the example of a platform developed during a 3-year project financed by European Union, whose outcomes has been rated with "Excellence". The R&D project is called "Bivee: Business Innovation in Virtual Enterprise Environments" and is part of the Factories of the Future FP7 project, subprogramme area: FoF-ICT-2011.7.3 - Virtual Factories and enterprises (http://cordis.europa.eu/project/rcn/100275_en.html). It engaged 9 European different partners until December 2014 and was devoted to the creation of an ICT platform tools for managing the innovation.

3.1. Approach

Dealing with a research for development project, aiming at linking theory and practice through research, the approach chosen to investigate phenomena is the Participatory Action Research (PAR).

Although difficulty and scepticism linked to the supposed lack of scientific rigour and discipline in action research and the difficulty of generalising results from this kind of study studies (McKay & Marshall, 2001), this approach appears to strongly fit the analysed case and the studied phenomena.
Indeed, by definition, action research aims to make organizational practice more effective while simultaneously building up a body of scientific knowledge in social science, involving the collaboration and co-operation of the action researchers and members of the organisational system.
The success of applying this research approach to this paper can be retrieved in Lewin's thought that causal inferences about the behaviour of human beings are more likely to be valid and enactable when the human beings in question participate in building and testing them" (see for example: Ragsdell, 2009; Coughlan & Coghlan, 2002; Brydon-Miller et al., 2003; Gummesson, 2000). In fact, in participatory action research the researcher can gain genuine insights into the organisation and, subsequently, can design and provide methods and tools to be adapted as the process progresses.
In particular, considering the phenomena taken into account in this paper, Ragsdell (2009) draw attention to the role that PAR could play in overcoming difficulties associated with developing a Knowledge Management culture and implementations. PAR process supports social networking, the creation of transparency and trust, ownership and organisational change.

In this research, two of the researchers were actors and agents of change, actively promoting and participating in the Bivee European Project (De Guerre, 2002). They designed the platform accordingly to Open Innovation principles and organized innovation processes having in mind SECI model phases. Consequently they conducted PAR real time, while the other two were involved ex post. In this way, it was possible to have a different point of view that could help re-elaborate facts in a traditional case study written in retrospect to have a "learning history" that could be used as an intervention to promote reflection and learning in the organizations (Gummesson, 2000).

3.2. The Bivee project

In particular, to this paper, the underlying approach of the project appears of particular interest since it was aimed at putting people in the center, with their creativity and competencies, providing a nurturing environment where open thinking and free interaction are more important than formal processes and stringent control (http://bivee.eu/).

Bivee project considers the Virtual Enterprise Environment defined as a temporary alliance of businesses that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks (Chesbrough,2006). And it takes in account and splits two different spatial dimensions: the Value Production Space (VPS) and the Business Innovation Space (BIS). While ideas for improvement are mainly created and elaborated in the VPS, pure or radical innovations emerge from the BIS. This corresponds to the idea of the coexistence of material and abstract components within the organizational innovation process and stresses the difference between improvement and innovation concepts and dynamics (Smith et al., 2013).

Concretely, the BIVEE project developed a distributed and collaborative platform of ICT services with two well differentiated scopes: the Enterprise innovation management and the production processes improvement of the SMEs. Indeed, the Bivee platform is based on:

- a **Mission Control Room**, for monitoring of Virtual Enterprises value production activities;
- a **Virtual Innovation Factory**, for managing the entire cycle of innovation ideas development;
- a **Production and Innovation Knowledge Repository (PIKR)** for providing a unified access point to heterogeneous knowledge resources (e.g., business processes, documents, technology, business domains, competitors).

Figure 1 Overview on the BIVEE framework. Adaptation from D2.2 "Specification of business innovation reference frameworks (in the context of the VEMF)."

The BIVEE Platform heavily relies on the collaboration of different skilled actors to successfully conduct an innovation venture. The embracement of an Open-Innovation approach further enforces this aspect, envisioning the participation of different stakeholders also belonging to the surrounding Business Ecosystem or even to the "external world".

Due to the high heterogeneity of networked organizations, the need of knowledge sharing, efficient access to knowledge resources, and interoperability technologies is faced as primary issue.

Not only does the platform support the social interactions happening through the BIVEE Environment, but also the discovery and categorization of web contents that could be useful in improvement and innovation activities (Smith et al., 2013), using the semantics-based infrastructure for management of digital documental resources.

At the same time, Bivee can provide also means for monitoring and measuring the success of any process improvement or innovation venture (http://bivee.eu/).

4. THE KNOWLEDGE CREATION PROCESS WITHIN BIVEE

The knowledge circle establishes the knowledge exchange interface between the Business Innovation Space and the Value Production Space and also describes how ideas are enabled as long as knowledge is advanced iteratively (Rossi et al., 2012: 14). It is based on the SECI-model by Nonaka itself. The process coming from Combination, Internalization, Socialization, and Externalization is carried out in both spaces.

However, implementing Open Innovation approach means bringing an important evolution in the SECI spiral model. Indeed, Bivee platform takes into account the inter-organizational dimension since the very beginning. So when considering knowledge creation phases, Bivee platform does not considers individuals or groups belonging to the same organization, but rather it involves individuals, groups and organizations acting in the same virtual space.

Figure 2 Ri-elaboration of Nonaka's SECI model to fit inter-organizational ontological level within a virtual environment.

Nevertheless, while aiming to describe the main mechanics, the knowledge circle is not meant to be a deterministic model. The BIVEE approach with respect to innovation tries to find a compromise between guidance and freedom; since the latter is the natural nurturing ground for innovation but in absence of the former it could be possible to encounter endless loops that are very risky in a business context. In order to give for some guidance to the innovation space, the BIVEE project divides and organize the Innovation Process in four main waves (Knoke, 2012). Indeed, the long tradition of innovation management of

analyzing and structuring innovation processes, has produced several schematizations and models, beginning with the innovation process conceived as a linear one, and finally evolving into a model based on feedback loops (see for example Veryzer 1998; Chiesa et al., 2009; Frankenberger et al., 2013; Penide et al., 2013; Kotha & Alexy, 2014).

Particularly, the underlying concept of waves in Bivee project, strongly characterizes it and differentiates it from linear phase models (Whitehead, 1926; Birkinshaw & Mol, 2006; Thoben, 2007). Indeed the concept of "wave" is not rigid and can support the variability and the recursiveness of the innovation process. Consequently, this implies that innovation process within Bivee project is rendered by four distinct moments that are not linearly subsequent and consecutive, but they can also overlap (Knoke, 2012: 21). In other words, Bivee model thanks to wave concept takes into account the fact that for example when in prototyping, it could be necessary going back to the feasibility or even starting the innovation process over.

Moreover, the main steps considered in these models are generally acknowledged in innovation management and, despite different nomenclatures and classifications, they are a constant within any innovation projects *lato sensu*.

- **Creativity**: starts with an innovation idea or a problem to be solved, providing a first sketchy idea to be developed. It mainly refers to creative activities and first connections.
- **Feasibility**: justifies the actual undertaking and the further development of the original idea in economic and operational terms collecting and providing the necessary information.
- **Prototyping**: produces a first implementation of the initial idea in the form of a prototype. The idea is drawn into the real world for the first time.
- **Engineering**: contains testing and overhaul-procedures. The original idea transformed into a prototype is attentively analysed to generate production and engineering plans (Taglino et al., 2012).

Figure 3 The four main waves of innovation. Adaptation from ROSSI, A., KNOKE, B., EFENDIOGLU N., WOITSCH R. 2012. D2.2 Specification of business innovation reference frameworks (in the context of the VEMF). *Deliverable of BIVEE Business Innovation Virtual Enterprise Environments European Project.* Available online: http://bivee.eu/download/ (accessed Aug. 11 2015).

Now, each of these waves can be considered giving birth to different but interrelated SECI spiral processes, that intertwine information flows with production ones, space of flows with space of places.

5. LEARNING HISTORY: FLUMEN INNOVATION PROJECT

To understand how the platform works and how the waves can be contextualized within SECI model, hereafter an example of a real Innovation Project is taken into account and described. This is a project developed in a realistic industrial scenario and conducted trough Bivee platform.

The project is called Flumen and is fostered by Loccioni Group, one of the BIVEE partners and end-user of the platform. Loccioni is a medium-sized Italian company specialised in technological solutions addressed to diverse clients and fields of appliance. Particularly, Flumen is a project aimed at developing a system for real-time monitoring of the bridge pier for the scour risk during flood.

Since Loccioni Headquarter is located next to Esino river and Scisciano bridge connects two of the main buildings of the Group, the need was to develop a robust and reliable system for objective monitoring, replacing decision processes based on subjective experience of technicians. The project leaded to the

development and set up of a monitoring system in order to control the phenomenon of pier scouring, a sedimeter called BLESS (Bed Level Seeking System).

Figure 4 SECI model applied to the four main waves of Flumen innovation project.

5.1. Creativity wave

Socialization. The project started with a specific request of Loccioni top management during an internal meeting with the Research for Innovation team (Loccioni internal team owed to develop long term research project and innovation). The team was asked to develop a monitoring system able to check for seismic vulnerability of the near bridge.
One of the Ph.D. engineer of Research for Innovation, had an intuition: the vulnerability of the bridge could be caused by hydro geological risk. She logged-in in the Bivee platform to insert the idea in the Virtual Innovation Factory and shared it with other engineers of the "innovation team".

Externalization. Loccioni Ph.D. engineer acknowledged that Scisciano bridge partially collapsed during a flood of the river Esino in the 90s, so she collected information about the causes. In the internal database of Loccioni Group, she found the technical report in which it was reported that the bridge collapsed for pier scouring problems. She shared the collected documents and she selected possible required competencies for this idea and found matching domain specialists among Bivee users.

Combination. The innovation team uploaded documents and added comments in the idea wizard (a kind of remote desktop where each member can modify, add, share documents and interact). As a results, they found two different technologies to measure the pier scour based on sonar and Fiber Bragg Grating (FBG).
Since all the requested fields were completed and a lot of documents uploaded, the idea was considered suitable for turning into an innovation project. At this point, both technical solutions were evaluated in light of existing literature concluding that the second solution (BLESS system) would be much reliable in case of flood, even if further improvement was required. After having checked out the marketing report and chosen KPIs to take into account, the innovation team submit the Innovation Report to Loccioni management.

Internalization. Loccioni management decided to go ahead with the feasibility wave of the project and the decision was noticed via mail. At this moment, the project switched to feasibility wave.

5.2. Feasibility wave

Socialization. Researchers and business people worked in cooperation to understand the technical and economic feasibility of the project. Technical solution proposed by the innovation team had to be improved and simplified to be engineered obtaining a performing and reliable system.

Externalization. Project and the sub projects were explained, specifying again the members of innovation team and the required competencies.
First of all, the innovation team chose the suppliers for components, looking for the best solution in term of cost and performance. Once found, the solutions were shared through the Bivee platform and suppliers became partners of the Loccioni VE and members of the innovation team. At this point, different components were tested before reaching a satisfactory solution.

Combination. Feasibility Study Report was prepared and uploaded it in the platform. The document included the state of art, the sub-projects, and the risk analysis and the cost-benefit analysis along with

some recommendations for the realization phases. Once the last technical aspects were discussed, the innovation team was ready to build the first prototype.

Internalization. Loccioni top management had to evaluate again the state of art of the project trough KPIs and documents. They understood that although the high risks, the project faced an actual and crucial problem which could involve both public and private aspects, and decided to go on to the prototyping wave.

5.3. Prototyping wave

Socialization. The Innovation Team started to build the first prototype, respecting the tight constraints on the budget while trying to maximize the reliability of the BLESS system. 5 sub projects were indentified: Bless system, civil project, electrical project, mechanical project, external heating circuit.

Externalization. The first tests conducted in the laboratory proved that the solution was really robust, flexible and reliable. All the subproject reports were completed in order to keep going with the installation. Then, when the system was installed on the Esino river bed, close to a pier of the bridge, technical problems occurred and one of the two arrays installed was broken. Fortunately, the two arrays were installed for redundancy.
As a result, the deviation from planned cost assumed a positive value but the results could be considered positive because the levels of risk and uncertainly were very high.

Combination. Bivee Prototyping Assessment Report was filled in presenting considerations and feedbacks to take into account during the engineering wave.

Internalization. After a long and detailed measuring campaign, the innovation team established that the improvements suggested for the system made it ready for the engineering wave.

5.4. Engineering wave

Socialization. Loccioni top management required a careful analysis of all the components to guarantee cost-effective selection of components for a profitable production of several units of the system. The results obtained from the prototyping wave showed that the cost for the components of this first prototype was too high. However, taking into account and analysing also strategic factors and market opportunities, the cost was considered acceptable in relation to the innovative potential of the system. So Loccioni management decided to go forward the engineered version of BLESS system.

Externalization. At the moment the project is still in the Engineering wave, waiting to realize the final version of the BLESS system for a new costumer. By the way, these data will be used for manage hydro geological risk and will be shared with public administration for damage evaluation and alert management.

6. CONCLUDING DISCUSSION

Nonaka's SECI (Socialization, Externalization, Combination, Internalization) model is the milestone of modern knowledge management conception. It moved the emphasis on individuals and their tacit and implicit knowledge. Nevertheless, the several contributions by Nonaka stop at an intra-organizational level of analysis. Little do they analyse about inter-organizational epistemological, and even less do they take into account the modalities of the implied interactions.

Consequently, there's room for drawing some interesting insights about the evolution of the spaces dedicated to knowledge creation, namely *ba*, taking into account the Open Innovation paradigm and considering organizations as cyber-physical systems.

In doing so, this paper was built around the Bivee project. The European project was aimed at developing a methodology to build a platform for sustaining and managing innovation linking different organizations in a virtual environment. According to PAR (Participatory Action Research) approach, the design of the structure of the platform itself was influenced *ex ante* by the willing to concretely apply Open Innovation paradigm and SECI spiral model for creating new knowledge. That was necessary in order to implement a practical solution that could lead to a better management of Open Innovation and to show a progress in the mentioned theoretical model for knowledge creation.

What came out from this research project is a methodology to develop structured and functioning platforms involving a network of different organizations. Particularly, this methodology is expected to design ICT platforms connecting different organizations and making them share and mutually grasp knowledge efficiently. Indeed it adopts a document centric approach which focuses on the documents exchanged during the improvement and innovation activities within a virtual enterprise (Taglino et al., 2012). The framework is built around two basic sets: a standard library which allows companies to set up environments for collaboration and process alignment, and a set of standardized semantically-defined metrics, which allows to quantify and benchmark processes from a strategic point of view (Rossi et al., 2012).

Moreover this methodology is aimed at managing Open Innovation processes following a wave partition that reflects the main steps acknowledged by any theoretical model for innovation processes. These purposes have given birth to a virtual platform model that could encompass and host all the knowledge creation phases at an inter-organizational level. Indeed, the learning history showed how all the phases of the spiral knowledge could take place in or be supported by a virtual dimension and result in physical or production dimension.

Significantly, Socialization phase in this kind of platform does not strictly require a physical interaction, but it is possible thanks also to ICT tools provided by the platform. Vis-à-vis interaction can be effectively replaced or supported by virtual interaction provided by rich media (McLuhan, 1964; Panahi et al., 2013).

Moreover the virtual environment makes it possible to overcome the single organization barriers since the very beginning. Indeed the interaction firstly among individuals and then among groups is not limited to one single company. On the contrary, implementing Open Innovation approach, individuals look for useful knowledge from outside the company and for individuals, groups or organizations that own this knowledge. Concretely, this result in a re-framing of the SECI model itself.

Therefore, if SECI model describes an incremental and gradual process from the epistemological point of view, starting with individuals, enlarging to groups of the same organization and eventually involving the whole organization (Nonaka, 1994), here things are different, involving inter-organizational interactions since the very beginning. Individuals and groups do not necessary belong to the same organization, but are interacting thanks to ICT tools in the same virtual environment.

Moreover, since the very beginning, the active participation of the different actors is sustained by a strong commitment and an explicit purpose. Being involved in the same research project or in the development of an innovative idea is the key issue to build up a common ground to enact interaction.

Of course, the fact that subjects belong to a common technical and technological background support the creation of the network and the rise of the needed trust (Takeuchi & Nonaka, 2004). Indeed this kind of ICT platforms can also cluster innovation ideas around different domains in order to gather similar competencies and backgrounds together and ease the evaluation process of technical solutions thanks to the presence of a domain expert. Nonetheless, a great heterogeneity of the network should be acknowledged, including for example both private companies and universities from different countries and integrating different fields of knowledge and expertise.

Obviously, strong links among individuals or organizations can be a prerequisite for the success of Socialization, that is to say of tacit knowledge sharing in virtual environment. However, interactions in virtual environments can be useful to establish weak links (Alavi & Leidner, 2001) or to strengthen the existing ones.

Indeed, modern ICT tools and platforms, are useful not just to store and retrieve documents or information, separating it from the owners, but bring individuals and social interaction back to the center of knowledge sharing and transfer, accordingly to Nonaka's conception of knowledge management. They represent a step ahead of ICT implementation, moving from information management to proper knowledge management.

Particularly, the platform model the article takes into account considers an Advanced knowledge repository (PIKR), that deals with explicit and digitalized enterprise knowledge to build up a collection of digital documental resources. The PIKR can provide, on one hand a set of reference structures (i.e., ontologies) for the semantic description of enterprise knowledge resources, and on the other hand, semantics-based services for accessing and reasoning over such descriptions. Consequently, here the term knowledge is mostly used to denote different kinds of information, documents content, competencies and skills of people, capabilities of an organization, expecting that the enterprise knowledge is largely in digital form (Taglino et al., 2012: 10).

Nevertheless modern ICT platforms should not just be made up of a knowledge repository to store and retrieve digitilized explicit knowledge. They should be developed with the underlying awareness that there is a part of the knowledge, often referred to as tacit knowledge, that remains concealed in the heads of people (Ibid., 9). For this reason, the platform model the article takes into account consists also of a Mission Control Room and a Virtual Innovation Factory that attempt to manage people's presence and interactions while involving a certain degree of tacitness of the knowledge that is exchanged and used to find solutions, take decisions and assess value (Šarkiūnaitė & Krikščiūnienė, 2005).

In this context, virtual dimension is always integrated with and have results in physical dimension. Therefore the spiral process of knowledge creation is always intertwining innovation and production spaces throughout the innovation waves.

Concluding, Bivee project developed a methodology showing how virtual spaces and ICT tools can be used to effectively enhance and support all the phases of SECI knowledge creation processes at inter-organizational level. Of course, the limitations of having taken into account just one single case of study are

evident, but analytical generalization is not the goal of this work; rather, along with the improvement of the organizational practice of the single project, the paper aims at theoretical generalization. Moreover having considered a generally widespread partition adopted in both any innovation projects' practical management and in theoretical model for innovation management, makes the model presented through the learning history easily theoretical generalizable. Indeed it is possible to effectively induce theoretical conclusions starting from the single case.

Particularly, it can be stated that considering the Open Innovation paradigm and the organizations being cyber-physical systems, Nonaka's *ba* categorization need to be updated. Thus it appears fundamental to include in the model inter-organizational interactions. Moreover it seems not correct anymore to speak about Cyber *ba* just to contextualize Combination phase. Accordingly, this work suggests to exclusively adopt the nomenclature Sistemising *ba* that Nonaka (Nonaka et al., 2000) used in one of his work to indicate the *ba* that hosts combination phase. Indeed all the SECI phases can take place totally or partially in virtual spaces, consequently all kinds of *ba* can be both physical and virtual.

Bibliography

ALAVI, M. & LEIDNER, D. E. 2001. Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS quarterly*, 107-136.

ALLEN, T. J. 1984. Managing the flow of technology: Technology transfer and the dissemination of technological information within the R&D organization. *MIT Press Books,* 1.

BALKA, K., RAASCH, C. & HERSTATT, C. 2014. The effect of selective openness on value creation in user innovation communities. *Journal of Product Innovation Management,* 31, 392-407.

BATTISTELLA, C. & NONINO, F. 2013. Exploring the impact of motivations on the attraction of innovation roles in open innovation web-based platforms. *Production Planning & Control,* 24, 226-245.

BIRKINSHAW, J. M. & MOL, M. J. 2006. How management innovation happens. *MIT Sloan management review,* 47, 81-88.

BRETTEL, M., FRIEDERICHSEN, N., KELLER, M. & ROSENBERG, M. 2014. How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. *International Journal of Science, Engineering and Technology 8 (1), 37,* 44.

BRYDON-MILLER, M., GREENWOOD, D. & MAGUIRE, P. 2003. Why action research? *Action research,* 1, 9-28.

BUGSHAN, H., IRANI, Z. & IRANI, Z. 2015. Open innovation using Web 2.0 technologies. *Journal of Enterprise Information Management,* 28.

CAMARINHA-MATOS, L. M. & AFSARMANESH, H. 2005. Collaborative networks: a new scientific discipline. *Journal of intelligent manufacturing,* 16, 439-452.

CASTELLS, M. 2005. Space of flows, space of places: Materials for a theory of urbanism in the information age. *Comparative planning cultures*, 45-63.

CHESBROUGH, H. W. & APPLEYARD, M. M. 2007. Open innovation and strategy.

CHESBROUGH, H. W. 2006. *Open innovation: The new imperative for creating and profiting from technology*, Harvard Business Press.

CHESBROUGH, H., VANHAVERBEKE, W. & WEST, J. 2006. *Open innovation: Researching a new paradigm*, Oxford university press.

CHIESA, V., FRATTINI, F., LAMBERTI, L. & NOCI, G. 2009. Exploring management control in radical innovation projects. *European Journal of Innovation Management,* 12, 416-443.

COUGHLAN, P. & COGHLAN, D. 2002. Action research for operations management. *International journal of operations & production management,* 22, 220-240.

DAVENPORT, T. H. & PRUSAK, L. 1998. *Working knowledge: How organizations manage what they know*, Harvard Business Press.

DAVIES, J., SURE, Y., LAUSEN, H., DING, Y., STOLLBERG, M., FENSEL, D., LARA HERNÁNDEZ, R. & HAN, S.-K. 2005. Semantic web portals: state-of-the-art survey. *Journal of knowledge Management,* 9, 40-49.

DE GUERRE, D. W. 2002. Doing action research in one's own organization: An ongoing conversation over time. *Systemic practice and action research,* 15, 331-349.

DONG, A. & POURMOHAMADI, M. 2014. Knowledge matching in the technology outsourcing context of online innovation intermediaries. *Technology Analysis & Strategic Management,* 26, 655-668.

FONG BOH, W., NGUYEN, T. T. & XU, Y. 2013. Knowledge transfer across dissimilar cultures. *Journal of Knowledge Management,* 17, 29-46.

FRANKENBERGER, K., WEIBLEN, T., CSIK, M. & GASSMANN, O. 2013. The 4I-framework of business model innovation: A structured view on process phases and challenges. *International Journal of Product Development,* 18**,** 249-273.

GUMMESSON, E. 1999. *Qualitative Methods in Management Research*, SAGE Publications.

HARGADON, A. B. 1999. Group cognition and creativity in organizations. *Research on managing groups and teams,* 2**,** 137-55.

HARGADON, A. B. 2002. Brokering knowledge: Linking learning and innovation. *Research in Organizational behavior,* 24**,** 41-85.

HÜSIG, S. & KOHN, S. 2011. "Open CAI 2.0"–Computer Aided Innovation in the era of open innovation and Web 2.0. *Computers in Industry,* 62**,** 407-413.

JAZDI, N. Cyber physical systems in the context of Industry 4.0. Automation, Quality and Testing, Robotics, 2014 IEEE International Conference on, 2014. IEEE, 1-4.

KNOKE, B. 2012. D2.1 State of the Art about the Collection and discussion of requirements for systematic Business Innovation and definition of KPIs. *Deliverable of BIVEE Business Innovation Virtual Enterprise Environments European Project*. Available online: http://bivee.eu/download/ (accessed Aug. 11 2015)

KOSTIAINEN, J. 2002. Learning and the 'Ba' in the Development Network of an Urban Region. *European Planning Studies,* 10**,** 613-631.

KOTHA, R., KIM, P. H. & ALEXY, O. 2014. Turn your science into a business. *Harvard business review : HBR,* 92**,** 106-114.

LEE, J., BAGHERI, B. & KAO, H.-A. 2015. A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters,* 3**,** 18-23.

LI, W. 2010. Virtual knowledge sharing in a cross-cultural context. *Journal of Knowledge Management,* 14**,** 38-50.

LOPEZ-NICOLAS, C. & SOTO-ACOSTA, P. 2010. Analyzing ICT adoption and use effects on knowledge creation: An empirical investigation in SMEs. *International Journal of Information Management,* 30**,** 521-528.

MARTÍNEZ-TORRES, M. 2014. Analysis of open innovation communities from the perspective of Social Network Analysis. *Technology Analysis & Strategic Management,* 26**,** 435-451.

MCKAY, J. & MARSHALL, P. 2001. The dual imperatives of action research. *Information Technology & People,* 14**,** 46-59.

MCLUHAN, M. & FIORE, Q. 1967. The medium is the message. *New York,* 123**,** 126-128.

NONAKA, I. & KONNO, N. 2005. The concept of "Ba": building a foundation for knowledge creation. *Knowledge management: critical perspectives on business and management,* 2**,** 53.

NONAKA, I. & TOYAMA, R. 2005. The theory of the knowledge-creating firm: subjectivity, objectivity and synthesis. *Industrial and Corporate change,* 14**,** 419-436.

NONAKA, I. 1991. The knowledge-creating company. *Harvard business review,* 69**,** 96-104.

NONAKA, I. 1994. A dynamic theory of organizational knowledge creation. *Organization science,* 5**,** 14-37.

NONAKA, I., TOYAMA, R. & KONNO, N. 2000. SECI, Ba and leadership: a unified model of dynamic knowledge creation. *Long range planning,* 33**,** 5-34.

PANAHI, S., WATSON, J. & PARTRIDGE, H. 2013. Towards tacit knowledge sharing over social web tools. *Journal of Knowledge Management,* 17**,** 379-397.

PENIDE, T., GOURC, D., PINGAUD, H. & PEILLON, P. 2013. Innovative process engineering: a generic model of the innovation process. *International Journal of Computer Integrated Manufacturing,* 26**,** 183-200.

POLANYI, M. 1967. *The Tacit Dimension*, Routledge & Kegan Paul.

POWELL, W. W. 1998. Learning from collaboration. *California management review,* 40**,** 228-240.

RAGSDELL, G. 2009. Participatory action research: a winning strategy for KM. *Journal of Knowledge Management,* 13**,** 564-576.

ROSSI, A., KNOKE, B., EFENDIOGLU N., WOITSCH R. 2012. D2.2 Specification of business innovation reference frameworks (in the context of the VEMF). *Deliverable of BIVEE Business Innovation Virtual Enterprise Environments European Project.* Available online: http://bivee.eu/download/ (accessed Aug. 11 2015).

SAENZ, J., ARAMBURU, N. & BLANCO, C. E. 2012. Knowledge sharing and innovation in Spanish and Colombian high-tech firms. *Journal of Knowledge Management,* 16**,** 919-933.

ŠARKIŪNAITĖ, I. & KRIKŠČIŪNIENĖ, D. 2005. Impacts of information technologies to tacit knowledge sharing: empirical approach. *Informacijos mokslai***,** 69-79.

SHVAIKO, P., OLTRAMARI, A., CUEL, R., POZZA, D. & ANGELINI, G. 2010. Generating innovation with semantically enabled TasLab portal. *The Semantic Web: Research and Applications.* Springer.

SIEBDRAT, F., HOEGL, M. & ERNST, H. 2009. How to manage virtual teams. *MIT Sloan Management Review,* 50**,** 63-68.

SMITH F., TAGLINO F., BARBAGALLO A., LUDOVICI V., ISAJA M. 2013. D5.4 Semantics-based Social Media for the Shared Production Control and Collaborative Open Innovation. *Deliverable of BIVEE Business Innovation Virtual Enterprise Environments European Project.* Available online: http://bivee.eu/download/ (accessed Aug. 11 2015).

TAGLINO, F., SMITH F., PROIETTI M.,ASSOGNA P., FORMICA A., SINACI A. A., DIAMANTINI C., POTENA D., GIGANTE F., PIERSANTELLI M., DI BERNARDO R. 2012. D5.1 Production and Innovation Knowledge Repository. *Deliverable of BIVEE Business Innovation Virtual Enterprise Environments European Project.* Available online: http://bivee.eu/download/ (accessed Aug. 11 2015).

TEE, M. Y. & KARNEY, D. 2010. Sharing and cultivating tacit knowledge in an online learning environment. *International Journal of Computer-Supported Collaborative Learning,* 5**,** 385-413.

THOBEN, K. 2007. LABORANOVA: Collaborative Innovation Vision Session 1: Mechanisms for Collaborative Innovation in Living Labs, ESoCE Net Industrial Forum, Rome, Italy, December 3.

TICKLE, M., ADEBANJO, D. & MICHAELIDES, Z. 2011. Developmental approaches to B2B virtual communities. *Technovation,* 31**,** 296-308.

TUOMI, I. Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. Systems Sciences, 1999. HICSS-32. Proceedings of the 32nd Annual Hawaii International Conference on, 1999. IEEE, 12 pp.

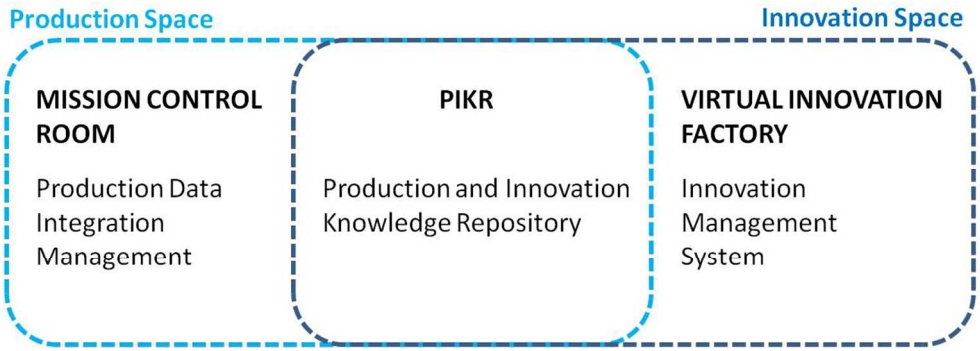
VERYZER, R. W. 1998. Key factors affecting customer evaluation of discontinuous new products. *The Journal of Product Innovation Management,* 15**,** 136-150.

WEI CHOO, C. & CORREA DRUMMOND DE ALVARENGA NETO, R. 2010. Beyond the ba: managing enabling contexts in knowledge organizations. *Journal of Knowledge Management,* 14**,** 592-610.

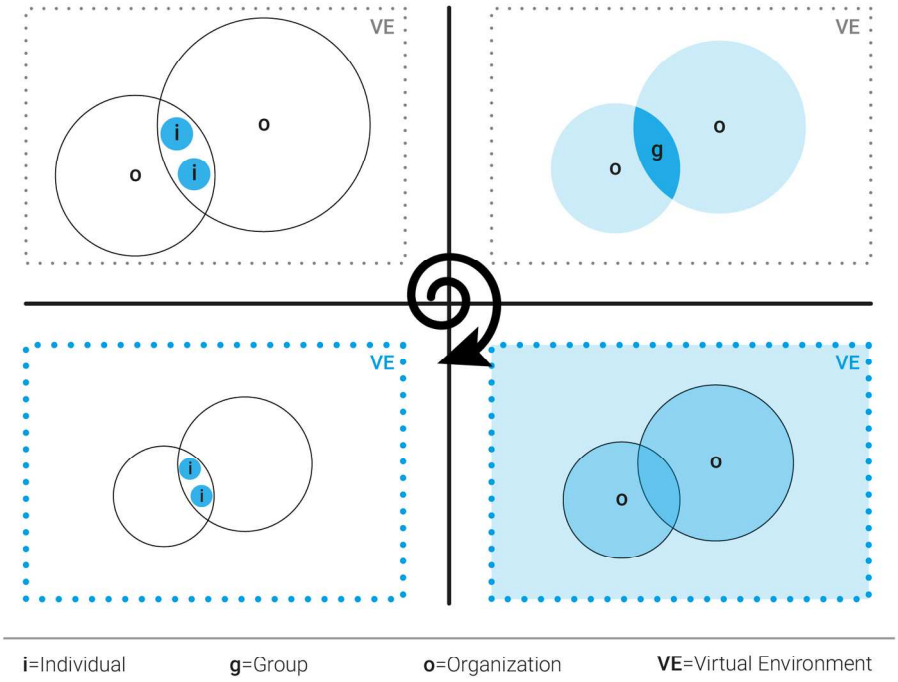
WHITEHEAD, A. N. 1926. *Religion in the making: Lowell lectures 1926*, Fordham Univ Press.

Ba	**Phase**	**Epistemological Level**	**Ontological Level**	**Knowledge Created**	**Needed Tools**
Originating *ba*	Socialization	Tacit – Tacit	Individual/ Individual	Empathic knowledge	Direct Interaction
Interacting *ba*	Externalization	Tacit - Explicit	Individual/ Group	Theoretical knowledge	Metaphors
Cyber *Ba*	Combination	Explicit - Explicit	Group/ Organizational	Systematic knowledge	Information Technology
Exercising *ba*	Internalization	Explicit - Tacit	Organization/ Individual	Operational knowledge	Learning by doing

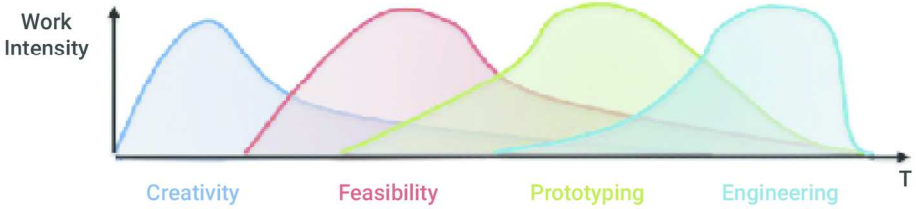
Table 1 Categorization of *ba* within SECI model.



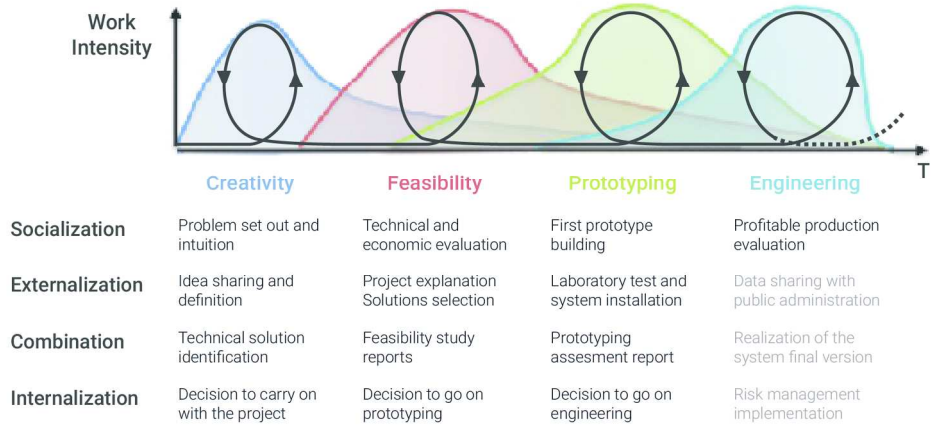
223x79mm (150 x 150 DPI)



169x134mm (300 x 300 DPI)



167x46mm (300 x 300 DPI)



176x85mm (300 x 300 DPI)