The Firm as a Knowledge-Creating Milieu: The Role of the ICT

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Abstract

This chapter concerns the interplay between the Information and Communication Technology and the collaboration mechanisms supporting knowledge creation, as investigated within disciplines like Computer Supported Cooperative Work and Human Computer Interaction. The chapter proposes three interrelated ways to characterize the spatial substratum of the firm's milieu: the physical and the virtual space; its local and the global dimension; and finally the kinds of artifacts that populate this space; then, it discusses the technology as a key element of the milieu by considering information systems and collaboration technologies. The conclusions claim that the technology should be used to manage the complexity of the target reality and not as a means to introduce simplifications for sake of a misinterpreted efficiency at the organizational and technological levels.

1 Introduction

This chapter articulates the role of the milieu for knowledge creation by taking the firm as the reference scale. A firm is considered as an organization characterized by a specific mission and a well recognizable structure of (human) resources: these constitute the specific affordances and constraints within which the firm plays its game to survive in its socio-economic context.

Moreover, the role of the milieu in relation to knowledge creation is discussed from the perspective of the influence that the Information and Communication Technology (ICT) can have in this ambit. This perspective leads us to focus on the

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collaboration that necessarily occurs among the members of the organization to let them meet the firm's mission. Indeed, collaboration is a common factor of both the creation of knowledge (interpreted as the outcome of a social phenomenon) and of the creativity and innovation that are essential conditions for the firm's survival. In this view however, innovation is considered as the outcome of a persistent and collective attitude to shift the existing boundaries (in terms of, e.g., processes, resources, pre-understandings) and not of isolated and possibly individual performances (that in any case can punctuate the former).

The contribution of this chapter concerns the interplay between the ICT and the collaboration mechanisms supporting knowledge creation, which have been understood in several years of empirical investigations of different working environments. This effort involves several disciplines, but the focus here is on the contribution of the CSCW (Computer Supported Cooperative Work) and HCI (Human Computer Interaction) research communities. The aim is to point to the risk to break those delicate mechanisms with the introduction of an inappropriate technology on the one hand, and on the other hand to the possibility to leverage those mechanisms to identify appropriate functionalities that can enhance their effectiveness. The risk is related to the capability of the technology to change the nature of the milieu where the organization's actors interact; the potentiality is related to the capability of the technology to change the dimension of the milieu in which these interactions occur.

First, the chapter proposes three interrelated ways to characterize the space that constitutes the substratum of the firm's milieu: the physical and the virtual space; its local and the global dimension; and finally the kinds of artifacts that populate this space. Some key concepts are introduced to capture the relevant features of knowledge creation according to these three dimensions. Then, the technology is discussed in its role of key element of the milieu: this will be done in the light of the risk and of the potentiality that the research efforts and our direct experience have identified. Two main classes of applications are considered: information systems and collaboration technologies. The traditional approaches by which these technologies are deployed in the firms are confronted with some more innovative proposals that have been defined at the research level.

The conclusions claim that the technology has to be used to manage the complexity of the target reality and not as a means to introduce undue simplifications. Indeed, the organization policy makers and the technology designers have a long way to go to keep the firm as a knowledge creating milieu in front of the organizational and technological evolution, or better yet co-evolution as these two facets are strongly intertwined.

2 Dimensions of the Milieu

In the discussion about the firm as a knowledge-creating milieu, we emphasize not only the social nature of knowledge but also its operational/pragmatic value: in other words, we consider knowledge creation in action, in its capability to respond

to the new demands that emerge from new situations. To this aim it is useful to identify some dimensions along which the notion of milieu can be articulated. These dimensions offer a perspective that is compatible with the connotation of milieu taken in this book (see the introductory chapter) in that they propose a transversal reading of the three mentioned constituents of a milieu: the spatial arrangement, the social volume and the relational density. Moreover, they implicitly make reference to time as an additional relevant constituent as synchronous and asynchronous collaboration have different characteristics and implications on knowledge creation. The dimensions serve as analytical instruments: they don't want to propose any undue fragmentation in looking at the reality. They are only instrumental to the discussion of the role of ICT as a resource for the firm's milieu to foster knowledge creation.

2.1 Physical Space and Virtual Space

The role of a shared physical space in positively or negatively affecting collaboration[1] that involves knowledge intensive activities has been emphasized by several studies that fall under the umbrella of the CSCW discipline. Collocated actors can combine verbal communication with a variety of nonverbal means of communication. This combination enriches the communication contents with contextual information about the communicating people and the environment in which they cooperate: this kind of information supports the interpretation of the verbal content in a very effective way (Heath & Luff, 1992).

Moreover, collocated actors can have a direct perception of the behaviour of the other actors involved in individual or collaborative activities. As in the previous case this perception can enrich the context of interpretation of these activities and make the collaboration and mutual understanding smooth. But more importantly, collocation allows the actors to carefully observe how the other actors carry on their activities: observation is a premise for imitation that, in turn, is a basic means for connecting learning with situated practices. This is even more the case when collocated actors jointly perform activities and in so doing collaborate to develop new solutions for emerging problems. The physical space is also very important when actors share it asynchronously: the spatial arrangements of the resources that are used in the collaboration (not only people, but also documents, folders, devices, instruments, furniture, etc.) is a means to understand the current state of affairs as well as the conventions and rules adopted to accomplish the collaborative tasks. A nice example of the role played by a spatial arrangement is reported in (Schmidt & Wagner, 2004) in the domain of architectural design.

The mutual and collaborative learning that is made easier by the sharing of a physical space is dramatically challenged when actors share a virtual space, i.e.,

[1] Recall that collaboration is here considered as a basic ingredient of both creativity and innovation.

with the mediation of ICT. The abovementioned learning practices cannot be put to work any more unless the technology is able to reproduce them or to offer valid alternatives (Churchill, Snowdon, & Munroe, 2001). The number of failures caused by the introduction of ICT solutions within organizations testifies how difficult is this goal (Warkentin, Moore, Bekkering, & Johnston, 2009). Failures concern both the management of the coordination of activities and of the information therein involved that collaboration requires[2]; but especially they concern the organizational and technological interventions that fall under the umbrella of Knowledge Management where big investments are seldom followed by an adequate ROI. The reasons of the failures in both situations are manifold and their discussion is out of the scope of this chapter. Here we point only to the simplistic view that often characterizes the adopted solutions, especially when knowledge management is concerned: the physical space is surrogated by a common repository where pieces of information are accumulated and organized according to some "universal" criteria that allow for their easier retrieval. But the physical space is not a repository or a store, as we discussed above. The term place (as opposed to space) was proposed to emphasize the relevance of the "contents" that live in a space: people, information, conventions, work practices, social relations and so on (Harrison & Dourish, 1996).[3] These contents allow actors to give meaning to whatever happens in that space. In the same vein, a poor metaphorical use of the term memory (interpreted as a repository) has been aptly questioned in (Bannon & Kuuti, 1996).

On the other hand, a virtual space overcomes some of the limits of a physical space. It can be arbitrarily extended to include new contents, to reach new people, to allow for their interactions. It can make information persistent and accessible from any-where and at any-time. It can be, at least in principle, flexibly modified and adapted to the current situation and personalized to the current actors' needs. This brings to the next dimension.

2.2 Locality and Globality

The second dimension captures the old and well known tension between local and global that can be observed in several disciplines (from economy to computer science, to mention the ones that are here more pertinent). This dimension has surely an impact when firms are concerned. Indeed, firms increasingly take the structure of a network whose nodes correspond to the distributed (in terms of location and/or mission) units constituting them. Even small firms face the global dimension when they expand their production or commercial relations worldwide. Indeed, the opportunity to make available to their members possibly differentiated

[2] The crash of the Information Systems installed in big organizations has been the object of alive discussions among the ICT experts in Italy in the last couple of years.

[3] As in the introductory chapter, also here the notion of place recalls the concept of milieu, although with a different disciplinary background.

virtual working spaces forces the firms to manage the tension between locality and globality: here we focus on the impact of this tension on the theme of knowledge creation.

Locality does not refer to the spatial dimension rather on the strength of the ties that link the people acting in the organization, although the spatial proximity can be an enabling condition for this strength. This characterization of locality is well captured by the notion of Community of Practice (CoP) that has been introduced by E. Wenger in the late 1990s (Wenger, 1998a) as a conceptualization of the successful practices of knowledge creation and mobilization which he had observed in several organizational settings. The ties that link the members of a CoP are described as follows.[4] First, the members have to share a common mission that incorporates the institutional activities but is not limited to them: the relevant part concerns the (tacit) negotiation of the conditions for their accomplishment (e.g., the mutual responsibility, rhythms, interpretations). Second, the members have to be mutually engaged in keeping the community alive according to the common mission and to support the (peripheral) participation of (new) members by recognizing the value of their heterogeneity and diversity. Finally, the members have to share a common repertoire, that is the routines, words, tools, modus operandi, stories, symbols, actions and concepts that the community has adopted or defined and that are a constitutive part of its practices. A CoP identifies a situation where learning and knowledge creation are likely to most probably happen. They are the result of an emergent behaviour that the hosting organization can at most recognize, sustain and valorise: a CoP cannot be "built". CoPs are fragile constructions that at every stage of their evolution[5] can break down because of unanticipated reasons that can be endogenous or exogenous. At the same time they can become so strong that their members can conceive their evolution toward new form of cooperation—new CoPs or less engaging constructions that suit better their needs- still preserving the old relationships and adapt them to the new situation.

As suggested in (Lesser & Storck, 2001) to build understanding of how a CoP can create organizational value, it is useful to think of it as an engine for the development of social capital (Nahapiet & Ghoshal, 1998). The notion of social capital defines a reference model to "compute" a particular value of a firm,[6] that is its capability to learn and create knowledge through three facets[7]: the structural facet refers to network ties, network configurations and organization; the cognitive

[4] This notion has been reformulated in many ways, often distorting its original definition and creating alternative names: see (Andriessen, 2005) for a summary of this plethora of proposals. Here we adhere the original definition.

[5] Wenger (1998b) mentions the following stages: potential, building, engaged, active and adaptive.

[6] It can also be used to "compute" the nature of the networks of companies that are the object of the analysis reported in the contributions of the second part of this book: from loose structures, up to districts, until interorganizational CoPs.

[7] We use the term facet instead of the original term dimension to avoid confusion with the local and global dimensions. An alternative connotation of the social capital (Adler & Kwon, 2002) calls the

facet refers to sharing of codes, narratives and language; and the relational facet refers to the level of trust that is shared among the collaborating actors (Huysman & Wulf, 2006). Both notions—CoP and social capital—point in the same direction: a locality—a kind of milieu—that is to some extent circumscribed by its capability to play as a rich context for the people living in it.

The global dimension aims at breaking this boundary and points to the less known, to the differences, to the definition of possibly more formal but surely less rich relationships. It is difficult to characterize the global dimension in a systematic way since it encompasses a variety of situations depending on the goal of who looks for it. We can consider two paradigmatic situations: looking for information and looking for new relationships. What is collected is in general semantically poor, magmatic, contradictory, difficult to use for the purposes of who is making the search: at the global level approximation and quantitative (statistical) methods guide the search and the identity of the searcher is seldom taken into account, if not again using these quantitative methods.

From our perspective, the above situations are characterized by a common aspect: the possibility to broaden the local view (with new ideas, new people, new stimuli, etc.) has to deal with the difficulty to fully appropriate the novelty since (at least) two rich shared contexts are missing: the one of the searcher and the one of the found item. In other words, the global dimension offers a (significant) support for accessibility (to information and people) but a little support for the selection and the interpretation of the results. The typical de-contextualization implied by the global dimension asks for an overhead of effort to put the obtained results to work in the context of who made the search (Prusak, 2001). As for the locality, also the global dimension is not related to any spatial features, in this case the distance: this can make things worse but distance is not a determinant. The true issue is the de-contextualization that takes place every time something is made accessible but is separated from the context that generated it or where its creator operates.

This is the very nature of the tension between the local and the global when learning and knowledge creation are at stake. People try to overcome the problems it generates by applying different complementary strategies. On the one hand, they leverage the little context that any information carries with it, that is what is often called metadata: the author, the time and the location of its production, and so on. From these pieces of information they try to enlarge the context supporting the interpretation and the appropriation of what they have found. On the other hand, an alternative strategy is to look not for the information itself but for who could posses it or point to the person who could know who could help solving the problem at hand (Ackerman, Pipek, & Wulf, 2003). Both strategies share the same idea: to bring again the global dimension to a local one, by reconstructing a context of interpretation. This practice has been captured by the so called SECI model

same three dimensions with the terms: opportunity, ability and motivation, that perhaps better explain their meaning.

(Nonaka & Takeuchi, 1995)[8] that emphasizes the continuous integration of external stimuli and contents with their individual elaboration, and can be extended from the individual and the group to the group and the organization up to the organization and the network of organizations.

Looking at the global dimension not as an undifferentiated *unicum* but as a network of localities could give a better picture of the reality and suggest better strategies for supporting learning and knowledge creation within distributed organizations, this way overcoming the separation between local and global (Ellingsen, Monteiro, & Røed, 2013; Lanzara, 1999). This could be translated into the motto: preserve localities, focus on their interactions, leverage the often invisible work and means (Star & Strauss, 1999) on which these interactions are based to improve learning and knowledge creation within distributed organizations. This would be a profitable way to combine the two theoretical contributions mentioned above and to complete the framework with an additional concept that focuses on the interactions among localities. To this purpose the notion of boundary object (Star & Bowker, 1999) has been introduced: a boundary object enjoys the property to be sufficiently robust (in its formal structure) to keep its identity in living in a controversial place (at the cross of the boundary) and sufficiently plastic to be useful for all the localities that share this boundary. This notion has been proposed especially to discuss the relationship between classifications and standards and to stress the need of "multiplicity" to avoid the creation of "monsters". However, the concept has become very popular and has been applied to more general kinds of interaction among communities, often distorting its original connotation, as the author complaints (Star, 2010). For this reason in the following we will use an alternative notion to avoid increasing this noise.

3 The Artifacts Populating the Milieu

The dimensions discussed in the previous paragraphs consider the capability of the space to enable the construction or the reconstruction of the context where facts, actions and information take their meaning. However, the contents of this context (that is part of the milieu) have been only marginally referred to. The artifacts that people build and locate in the space play a relevant role in defining the context for the sense making that supports their collective action and knowledge creation. The nature of these artifacts is one of the relevant outcomes of several studies of the work practices that make collaboration smooth in routine and in unexpected situations: these studies have been conducted especially in the CSCW ambit

[8] SECI stands for "Socialization, Externalization, Combination and Internalization". This model has been criticized [see e.g., (Wilson, 2002)] for been too simplistic and unduly prescriptive with respect to the complexity of the learning by individuals. We share in part these criticisms but we believe that they are often based on a biased reading of the sometimes imprecise definition of the proposal.

(Kuutti, 2013). On the basis of these studies the role played by these artifacts is hereafter analysed in more detail.

There are artifacts whose role is to objectify the state of a collaborative distributed process: they can be called *coordinative artifacts* since they more or less explicitly show what has already been achieved in the process and what remains to be done and by whom. Examples of coordinative artifacts can be found in any situation where a (semi)structured document is "circulated" among stakeholders that inscribe it and in so doing let the collaborative process progress. For example, a bug report that coordinates the testing phase of a software product (Carstensen & Sorensen, 1996); a card that coordinates the work distribution in a (kanban) production system (Schmidt, 1994); or a Patient Record that is a web of artifacts that coordinate the care process at the patient bed among doctors and nurses (Bardram & Bossen, 2005).

There are artifacts whose role is to induce people to turn their attention to a specific fact or situation to make collaboration smooth and more situated in the current context: they can be called *awareness promoting artifacts*.[9] Examples of this kind of artifacts are typical alarm devices but also bulletin boards for different usages: from the explicit information contained in the list of approaching trains in a railroad station up to the more implicit and sometimes messy (for the external observer) information jotted down on a whiteboard in a hospital ward (Xiao, 2005).

Finally, there are artifacts whose role is to make permanent part of a repertoire that (typically) a CoP has defined and wants to explicitly share among its members: they have been called *knowledge artifacts* in (Cabitza, Colombo, & Simone, 2013) where they have been defined as[10] "a physical, i.e., material but not necessarily tangible, inscribed artifact that is collaboratively created, maintained and used to support . . . knowledge creation and exploitation, collaborative problem solving and decision making *within or across communities of practice*; . . . the representation language and the representations shared in such a knowledge artifact allow for an affordable, continuous and user-driven maintenance and evolution of both its structure and content *at the appropriate level of underspecification* (emphasis added)".

This definition allows for a uniform characterization of different situations in which members belonging to one or more CoPs interact to collaborate and put their knowledge in common. In the same paper two examples of knowledge artifacts are described: we point the interested reader to it for all the details. In both cases the knowledge artifacts were created to support the design of the product that characterized the mission of the organization: they were about the core knowledge that should at the same time make the reuse of past design experiences easier and foster the creativity toward the identification of innovative features by an

[9] The rich notion of *awareness* for sake of improving collaboration is thoroughly discussed in (Schmidt, 2002) and in the papers contained in the related special issue.

[10] This term has been defined in different and contradictory ways in the literature: for this reason we clarify the one we refer to in order to avoid misinterpretations.

interdisciplinary community of designers. In both cases the representation language and the constructed representations were based on a very limited (although open-ended) set of conventional symbols that denoted the "few aspects" and the "few relations" among them that the designers deemed as really matter in "their" interdisciplinary design practices for innovation in the two target application domains. The knowledge artifacts were highly underspecified if compared with the complexity of the problems at hand; however exactly this underspecification was a successful means that the designers used to generate new ideas and to create the new products without being laded with the useless details of each discipline. The underspecified artifacts were cheap to maintain, flexible to changes and extremely effective to sustain the interdisciplinary design because they had been constructed bottom-up, from the shared design local practices. In one of the two cases, a slightly modified version of the knowledge artifact[11] played the role of boundary object between the community of the designers and that of the people involved in the production of the innovative products. Interestingly, the same representations that were the starting point of innovation for the designers community were used to reach the opposite goal by the other community: the uniformity of the production. In other words, the "object" was sufficiently robust to survive the crossing of the border between the two communities and sufficiently plastic to be useful for them to fulfil their different goals.

We conclude this section with a consideration that holds for all the kinds of artifacts presented above. On the one hand, they are not so easy to be identified within an organization: the mechanisms that make them effective are often incorporated in the so called invisible work (Star & Strauss, 1999) that escapes a superficial analysis of the organizations [too often driven by a top-down approach that takes the management perspective only: the management trap mentioned in (Huysman & Wulf, 2006)] or that are unduly confused with the artifacts that are the institutional outputs of the business processes; on the other hand, for their very nature, they are the "killer factors" for the design of useful and usable technologies supporting collaboration and knowledge creation as they capture the true practices that make the organization survive and smoothly reach its mission.

4 The Role of the Technology

The previous sections should have clarified that the technology is a very influential component of the milieu as the ICT can have positive and negative effects on the collaboration (as a vehicle for knowledge creation) that happens in the milieu the ICT contributes to "augment". The point we want to make is that too often the technology is conceived and constructed with little consideration for its impacts on the milieu in which it is deployed: this is probably one of the basic reasons why we

[11] Basically, with the same structure but without the contents that were sensible for sake of innovation.

can observe small successes, if not failures, especially when knowledge is involved in the activities it supports. In speaking of technology it is useful to consider both the solutions that are available on the shelf or constructed for specific organizations and the solutions that are proposed by the research community: in the latter case the solutions reach the status of prototypes sometimes validated in real or realistic settings. Incidentally, in this way the issue of innovation can be looked at in this specific disciplinary (and economic) sector.

An evident issue concerns the tension between the real and the virtual that has been illustrated in the previous section. The evolution of the computational infrastructure (both in terms of transmission bandwidth and of computing power) suggested the idea to construct a virtual context that reproduces the real context: either directly (after the seminal work presented in (Benford & Fahlén, 1993) or metaphorically (Second Life[12] offers a typical approach). The resulting technologies did not meet their objectives: the technology was creating an expectation that the simulation did not fulfil. In the first case, the inhabitants of the artificial shared space were too limited in reproducing the richness of the verbal and non verbal languages the actors use in the real space; in the second case, the metaphoric virtual space was not easily integrated, at least cognitively, with the real one: this resulted in a useless duplication and in an overhead of cognitive effort that did not make sense in real organizational settings. In the course of the years, these technologies have changed their target: from supporting work to support mainly entertainment and education (Benford, Magerkurth, & Ljungstrand, 2005; Boulos, Hetherington, & Wheeler, 2007).

Then, the more practicable solution for ICT to support collaborations within distributed organizations has not to be sought in reproducing the real contexts but in offering alternative contexts, different from those ones but hopefully equally effective.

Within a firm two kinds of activities are nowadays supported by consolidated technologies: the activities that collect and make permanent the data that support the mission of the firm, and the meetings: the former are the realm of the database transactions; the latter are now made possible by connection-wise powerful videoconferencing tools. In database transactions people are marginally involved; videoconferencing tools make the technology disappearing (if the connections work!) and offer a mere memorization of what was going on. In-between there are the technologies where the interactions with the users and among the users is at core of the problem, that is where the context comes to the scene to support the sense making and the sense giving and therefore are still looking for adequate solutions: information systems and collaboration technologies. The former are focused on recurrent situations, on the availability of information and on its quality (Carlo Batini, Cabitza, Cappiello, & Francalanci, 2006); the latter are focused on emerging behaviours, on the negotiation of what is at stake and what has to be done in response to—and on how to deal with—situations that can be only partially

[12] http://secondlife.com/

anticipated. The question is then: which is the influence of these technologies on a knowledge creating milieu?

4.1 Information Systems and the Milieu

In the information systems ambit, the main representations of the knowledge therein involved are the conceptual models capturing the core of the application domain (information and processes) and how they are reified within the technology. Two main situations are relevant in this context in relation to knowledge creation.

The first situation encompasses the case when conceptual models have to be integrated in consequence of the firm evolution: the typical example is the merging of two organizations; or in consequence of the need to make information system interoperate for sake of information exchange to support services or cross checking: the typical example is the case of the Public Administration whose information patrimony has usually grown in a not systematic—if not chaotic—way that however takes into account local cultures and needs. The answer to this kind of breakdowns is usually found in approaches that aim to construct a conceptual model that, in a way or another, unifies the source ones (Batini, Lenzerini, & Navathe, 1986): this unification forces structural changes in the involved models, which have of course semantic and pragmatic implications. An alternative approach, that is taken by the current development of the so called Linked Data (Heath & Bizier, 2011), is to add levels of structure on top of the ones to be integrated: this increases the complexity of the solutions (Freitas, Curry, Oliveira, & O'Riain, 2012) and is likely to generate a sort of domino effect that involves the added layers. Despite their technical differences, these approaches are conceived trough technical tools (algorithms, heuristics) without considering the impact their application might have on the work practices of the target organizations. The breakdown generating the integration is not taken as an opportunity to compose the knowledge related to different work practices, to define changes as a compromise based on their reconciliation, to obtain a result that is more that the sum of the two parties in term of knowledge and learning. The value of a consistent and efficient result overcomes the cost of loosing part of the local knowledge and the related work practices. In other words, the attention is put on the uniformity of the abstraction instead of on the different contexts where the abstraction has to be interpreted. It is worth noticing that recently the academic research started a reflection on this issue in the framework of the most sophisticated approach to domain modelling, namely ontologies. Despite the rich semantics that they are able to express through concepts and relations among them, some authors start claiming that a deep interpretation of the constructions that make use of a given ontology requires a description of the context in which the ontology has been used and defined, also within the same application domain (Pike & Gahegan, 2009). This means that the straightforward translation of a conceptual model from a place to another in the milieu is risky as it fallaciously presupposes a common understanding at least of the very general concepts and relations. In addition, this means that a

reflection on what can be considered as pragmatically "the same" is likely to be part of the negotiation of the work practices to get things done (i.e., it should become part of the shared repertoire).

The second source of breakdown arises when the conceptual modelling incorporated in an information system does not fit the local needs: either because it is too rigid, to far away from what is needed in contingent or transient situations, or because the firm cannot afford the effort of its creation (typically, in the case of SMEs[13]). These two cases are generated in different circumstances: the first one as a sort of workaround to overcome the limits of the imposed technology; the second one as the response to the need to have an affordable technological support. However, the two cases share how the solutions to deal with the problem are created: their genesis reflects a bottom-up approach that is in the hands of the actual users of the information. Indeed, they create "their" applications that fit "their" needs, irrespective of any big system or of their limited technological skills. These applications have been "called shadow applications" because they are unrecognized as well as do the effort to construct them and the advantage they bring the organization effectiveness (Handel & Poltrock, 2011); these applications are built by using flexible tools that can be put to use, at least to some extent, by laymen in ICT.[14] What matters here is not whether these applications are efficient, well engineered or developed with sound methodologies: what matters here is the knowledge they testify, the learning process they trigger in the "*bricoleurs*" (Cabitza & Simone, 2015; Ciborra, 1992) constructing them: this knowledge concerns both the application domain and the technological issues that constitute the "infrastructure" (Pipek & Wulf, 2009) of the target milieu. This kind of knowledge and learning is almost disregarded by the official design practices although it could play a fundamental role in the design of applications that are likely to avoid the recurrent technological failures we mentioned above. The knowledge and learning of this kind are also disregarded by the management: either because it does not perceive their value or because the firms (specially the SMEs) usually don't reflect (and invest) on how to improve the management of their knowledge (re)sources.

4.2 Collaboration Technologies and the Milieu

Under the umbrella of collaboration technologies fall the applications devoted to manage information sharing (semi-structured information and documents), communication (threads of conversations) and partially business processes (structures

[13] EU SMEs in 2012: at the crossroads *Annual report on small and medium-sized enterprises in the EU*, 2011/12.

[14] This is what makes tools like spreadsheets killer applications within organizations. Moreover, this need triggered a research line called End User Development (EUD; Lieberman, Paternò, & Wulf, 2006) that proposes different solutions for an effective user involvement in a true "socially embedded technologies" development (Cabitza & Simone, 2015).

of coordinated activities).[15] The market offers off the shelf solutions that can be grouped under the Web 2.0 keyword[16]: these solutions can be customized to make their typical social networks functionalities fit different organizational settings, from general network of interest up to more structured distributed organizations. Since our goal is to articulate how these technologies impact the milieu for knowledge creation it is useful to make this analysis using the dimensions/facets of social capital that have been introduced in the previous section. We agree with (Huysman & Wulf, 2006) that most of the functionalities of the Web 2.0 applications are oriented to the structural dimension. Actually, accessibility to multimedia information and to people through different devices is the main goal as well as the notification of a series of events that concern them (update, modification, presence and the like). Very often these applications are introduced into the firms for sake of Knowledge Management as if searching, retrieving and reaching information and/or people would suffice to this aim. More rarely, the resulting Corporate Social Networks[17] are introduced with the by far more realistic motivation (and ambition) to trigger best practices that could play the role of an enabler of more effective knowledge sharing behaviours among the network's members (Alberghini, Cricelli, & Grimaldi, 2013).

The true problem with this class of technologies is that it is oriented more to the accumulation of information than to the construction of a context for its interpretation. This latter requires paying attention to the local practices, to identify specific application domain requirements, to reflect on the adopted design strategy: in other words, it requires an effort that is not limited to a shallow customization of general purpose and nowadays standardized functionalities.

An example of this more articulated approach can be found in the IBM project that, starting from the observation of this complex organization and from the "practical techniques that have to do with the cognitive and social factors that come into play in the creation and communication of knowledge", conceived a series of technologies, among which one that is called Babble, and that was deployed within the IBM itself (Thomas, Kellogg, & Erickson, 2001). This technology falls under the structural dimension of social capital as it handles synchronous and asynchronous communication; however, its innovative functionality is devoted to what is called "social translucence", that is "the creation, exercise and mutual observation of social behaviour". Babble supports the ongoing conversations by making visible in a visual way the level of people's participation,

[15] Nowadays, business processes management is a component of an information system. Here we consider a light version of it, that is the management of processes that are embedded in other collaborative applications and have in general a reduced complexity.

[16] Actually, we could also mention the Web 3.0 solutions that endow the former with Semantic Web functionalities, that however show the same criticality mentioned before regarding conceptual modelling, specifically ontologies.

[17] A Corporate Social Network is in general a WEB 2.0 application that is implemented on a platform that guarantees secure and constrained access rights compliant with the corporate's policies.

the involved topics and the current messages; moreover, Babble supports asynchronous communication by memorizing conversations and by making them accessible through a timeline that shows the communication peaks, who was involved as a speaker or a listener in the hot topics. This persistent and situated representation of the conversations is a resource for a reflection on what was going on: this reflection could foster a more aware participation in the collaborative processes as well as in the learning process of how topics were handled in a more or less successful ways.

Examples of technologies that refer to the cognitive and relational dimensions are more difficult to find: this is not surprising since these dimensions have to take seriously into consideration the context where these technologies are put to work. In consequence of this, these technologies are more dependent on the application domain (although some generalization could be possible if they are suitably designed), if not unique to the situation for which they have been conceived: hence, usually they are not widely spread and sometimes their description is not accessible at all, unless they have been constructed within research projects that document them.

An interesting example of a technology that has been demonstrated for a specific application domain is EDC (Envisionment and Discovery Collaboratories), although its architecture could support the translation of its main functionality in other application domains (Arias, Eden, Fischer, Gorman, & Scharff, 2000). Two are the main intriguing features of EDC whose combination supports the so called "action-reflection" loop, that is an elaboration of the "reflection-in-action" principle (Shoen, 1992). The first feature allows the actors to blend the physical and the virtual representation of the problem at hand (Fig. 1). Problem solving happens around an interactive table that is able to recognize physical objects positioned on it. In the experimental case, the issue was an urban planning problem, the table offered a map of the target territory and the objects were the typically involved entities: houses, bus stops, plants, gardens and the like.[18] This blended representation allows an easy interaction among interdisciplinary experts by supporting a "problem solving by playing" with the physical objects and by testing the current solution through the (software) simulation of its consequences on the overall environment. Actually, the technology let them focus on the common action (basically, a try-and-error approach) as a means to overcome the disciplinary differences and reduce the hopeless alignment of the different languages and the endless discussions about the premises of an optimal solution (e.g., a priori domain models). Here again, the underspecification of the blended representation plays a fundamental role in knowledge creation and innovation.

The second intriguing feature of EDC is the space for reflection that is separated from the space for action and at the same time is connected to it through the memorization of "experimented" solutions and the recovery of the (new) configurations produced by the reflection. Hence, action and reflection have the

[18] The current technologies could implement the same ideas in an easier way form the technical viewpoint; however the idea is still innovative and poorly supported by general purpose platforms.

Fig. 1 The action-reflection space in EDC (Arias et al., 2000)

same relevance in problem solving: the former look for a solution by applying existing "codes"; the second elaborates the proposed solutions and feeds the creation of the next one, possibly changing these codes. The reflection can be individual or collective; therefore this change can be the object of a negotiation: in any case it is a contribution to the evolution of the solution, that is a reflection-in-action.

There is an evident tension between the costs and benefits of an ad hoc-solution and those of the customization of a general purpose technology: one might wonder if a compromise can be reached. A possible way to find it is to reinterpret the role of some functionalities that are offered by the general purpose technologies (specifically, the above mentioned WEB 2.0 ones) in the light of the reflection-in-action principle, that is in the light of constructing a space that creates a context for interpretation and reinterpretation.

The introduction of WEB 2.0 technologies within the firms was motivated by the need to make the organization members actively contribute to the contents of the shared information space, typically to collect their work experiences: this is usually done by asking users to tell the story of the more significant episodes of their working life. The available means for this purpose are in general based on almost unstructured texts (produced as uploaded documents or constructed through any sort of writing tool of the platform) that are sometimes difficult to read and surely impossible to retrieve and compare in an efficient way for sake of re-use: the problem at stake is that action is fully separated from reflection, that is without any temporal or logical direct connection. A possible way to overcome this limit could be to define some general structures for these stories that take into account the goal for which they are told, their internal narration and plot, and how each story can be put into relation with other stories (as an enrichment, as a counterexample, as an evolution, etc.). To this aim the above mentioned IBM project aimed at defining a Story Markup Language (StoryML) by which to annotate the story contents according to these criteria. This is an interesting idea that however can generate

all the problems that any sort of standardized conceptual scheme is likely to raise (as already discussed). A by far less problematic solution would acknowledge and leverage the fact that work practices are often flanked by the usage of artifacts of the kind we have already described. Then, why not to tell the story "around" those artifacts leveraging a very common habit, that is adding annotations? Actually, almost all WEB 2.0 platforms support them with a dedicated functionality that allows one to share annotations among the platform users. Of course, this functionality should be reinterpreted in the light of the new goal: currently, annotations are supported as a marginal content that is not worth being valorised and made persistent, that is as a sort of scaffolding that has a limited usage and value.[19] On the contrary, they are a powerful means to keep trace of important pieces of information in a contextualized way though the links connecting them with the artifact in use; this is the case also when annotations are added after the use itself as the information inscribed in the artifact is able to recall in the mind of the competent actors the situation that was contextual to the inscription. In the light of this interpretation, an adequate functionality should allow a rich set of ways to link annotations to the source artifact and also to link annotations with other annotations (Cabitza, Simone, & Locatelli, 2012): this second possibility could be exploited to express conversations about a topic thus allowing a collective reflection, a negotiation of meaning; or to express stories when each annotation describes a particular frame of the overall story: in this case the links can generate an open-ended set of narrative structures, far beyond a predefined markup language.[20] Moreover, as annotations can be constituted of semantic tags (that is elements of predefined taxonomies) they can express relationships among the annotated sources and build a rich and annotated web of documents. Finally, as (semantic) annotations can have associated threads of conversations (as alluded above) they could support the collective definition of the meaning of those tags: in so doing, they help alleviating the rigidity of any conceptual model, however expressed, by creating a local context of usage of those tags.

5 Conclusions

The chapter started with the identification of some dimensions characterizing the milieu for knowledge creation when the perspective of a firm is taken (as a complement of other perspectives that consider different scales). These dimensions have been described leveraging some concepts and models that are currently used to investigate the theme of knowledge creation within organizations. The identified

[19] Typically, the annotation interface contains a cue (a tick icon) to check the annotation and make it disappear as "approved" or as "irrelevant", by the way without distinguishing between the two opposite meanings.

[20] Some available platforms allow one to associate a forum or to add a thread of comments to a resource (e.g., a document): however it is evident that this is a banal reuse of functionalities that have been conceived for other purposes and are quite rigid with respect what is proposed here.

dimensions and the related concepts serve as a background for the understanding of how the ICT can influence the milieu where knowledge creation takes place: ICT is nowadays a fundamental component of this milieu and can deeply influence its capabilities in reaching this goal. The picture shows contrasting trends that are motivated by the complexity of the problem at hand whose solution requires a deep understanding of the local situations and work practices: this investment is often considered as too expensive and generic solutions are adopted by applying a less demanding approach—let's make something available and let's see what will happen. The true risk is that the endeavour to support knowledge creation and innovation (that however requires a relevant effort as it involves organizational and technological issues) will not generate an acceptable ROI since knowledge promoting technologies can be simply forgotten or easily circumvented if perceived as not fitting the local needs; thus they are unable to generate the critical mass that is required to make them effective for the people and the organization they should support. The limits of this approach is also testified by the kind of analysis that follows the introduction of the technology as it is reported in the scientific literature[21]: the most used parameters refer to quantitative indicators like the number of accesses for each offered functionality, or to generic qualitative indicators such as the user perception of the utility or usability of the system, although some more adequate approaches have been defined (Rao, 2005). There are no indicators to investigate the real impact of the new augmented milieu on knowledge promotion and creation within the organization: the impact could be positive or neutral but also negative as an inadequate technology can break the good work practices and their delicate mechanisms. This phenomenon should be recognized and contrasted as soon as it appears.

Then, the organization policy makers and the technology designers have a long way to go to keep the firm a knowledge creating milieu in front of the organizational and technological co-evolution. This co-evolution should lead to a milieu that is open without imposing uniformity; where things are not searched for but collaboratively constructed; where this construction is traced and made persistent as part of the common repertoire; where the real and the virtual coexist in a harmonic way, thus cleverly bringing the Internet of Things (Atzori, Iera, & Morabito, 2010) in the organizational ambit; where the technological and organizational support of information management, collaboration and knowledge creation is conceived as a unique entity, as a unique goal (Cabitza & Simone, 2012; Newell, Huang, Galliers, & Pan, 2003).

[21] The results reported by other sources are in general biased in favour of the success of the initiatives, with little attention to a critical view of their outcomes.

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