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Capturing that “tacitness” of work practice: Implications to IS-design from a social learning perspective

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Abstract
IS-development efforts targeted for capturing and supporting knowledge sharing and learning processes within the social context of the work practice are in still their advent and lack proper theoretical foundation. These processes are vital to an organization as they are the sources of its innovative power and strategic survival. What an organization knows is embedded within the people constituting that very same organization. How this knowledge is generated, shared and applied in problem solving situations of an organization’s daily work is rooted within the social context of the practice. There do exist examples of work in done this direction in formulating guiding principles for IS-design of support systems, but we find that they are not adequately addressing the social dimensions of practice. Here we try to remedy this by drawing upon social theory of learning in search for implications for IS-design. This theory has shown great explanatory power for processes of knowledge sharing and learning within the social context of the work practice. In this paper, it is used together with lessons learned from a development project in laying a foundation for IS-design principles.

Keywords: IS-design, knowledge sharing and learning, and social theory of learning.

1. Setting the scene

In spite of the intriguing title, this is not yet another paper about capturing that elusive tacit knowledge generated from organizational activities in order to turn it into something that may generate business profit in some form or another. We are not adhering to any of strategies for the management of knowledge as pointed upon by Hansen et al. (1999) of either codification or personalization, nor are we aiming to provide with formalized models of knowledge transfer in order to make the organization a more effective machine, as Dixon (2000) in her work has done. We do recognize that capturing and sharing of knowledge generated from organizational activities is important to an organization’s strategic survival, as it is a source of its innovative power (Davenport and Prusak, 1998).

The issue addressed through this paper is much in line with the work of Markus et al. (2002) concerning the design of support systems for knowledge processes. In finding that current designs efforts of IT support do not adequately address the characteristics and demands of organizational knowledge processes, they develop guidelines that may direct the design process. However, in heeding the call of Orlikowski (2002) for a view of organizational knowledge as a process of knowing inseparable of action, and recognizing that knowledge, derived from experiences generated through previous problem solving, is socially constructed and situated as well as directly related to the problem situations at hand, see (Brown and Duguid, 2000; and Lave and Wenger, 1991), we find that the theoretical foundation of the “design theory” of Markus et al. (2002) does not adequately address the social dimensions of knowledge sharing and learning in practice.

In addressing the need for theoretical support in directing our development efforts we turn to the work of Wenger (1998 and 2000). His work, concerning social theory of learning and social learning systems, addresses issues of learning and working within the social context of practice, and shown to have great explanatory power. In looking into how this theory may contributing as a “kernel theory” in formulating design principles guiding our development efforts we explore it in relation to the lessons learned from a development case at large telecommunications company. The aim of the project was to develop a tool that supports security specialists in their daily work of vulnerability analysis of different plants. Here, the support
tool serves as help in documenting the actions taken during analysis work, organizing information, as well as serving as a forum for discussion, promoting learning and sharing of meaning through the exchanging of experiences.

The paper is organized as follows. We will begin by presenting the ideas and work that have influenced and inspired us. Here, four strands of thinking converge: the work Orlikowski (2002) of knowing in practice; the work of Wenger (1998 and 2000) concerning communities of practice and social systems of learning; the work of Markus et al. (2002) on emergent knowledge processes and design principles; and, finally, we will return again to the work of Wenger (1998) on the design for learning. Then we will present our development case and summarize the lessons learned. Finally, we conclude this paper with a discussion of the lessons learned in relation to social theory of learning in laying a foundation for design principles.

2. Knowing in practice

“Knowledge is less about truth and reason and more about the practice of intervening knowledgeably and purposefully in the world.” (Spender, 1996, p. 64)

In defining our view of knowledge in relation to practice, we will draw upon the work of Orlikowski (2002). Her work is much influenced by the sociological work of Giddens (1984), and the anthropological work of Lave (1988), Hutchins (1991 and 1995), and Suchman (1987). She also draws upon the work of Schön (1983) on how professionals learn in practice, and the work of Polanyi (1967) on the tacit dimension of knowledge. In her work, she focuses upon the processes of organizational knowing rather than knowledge as such. She sees organizational knowing as emerging from the ongoing and situated actions of organizational members as they engage the world, thus highlighting role human actions in knowing how to get the work done. Her perspective suggests that knowing is not a static embedded capability or a stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world in everyday practice.

According to Orlikowski (2002), knowledgeability, or knowing-in-practice, is continually enacted through people’s everyday activity; it does not exist “out there” (incorporated into external objects, routines, or systems), or “in here” (inscribed in human brains, bodies, or communities). Here, the process of knowing cannot be understood as stable or enduring as it is enacted in the moment, its existence is virtual, and its status provisional. The “knowing how” to accomplish things manifests itself as capabilities generated through actions. They emerge from the situated and ongoing interrelationships of context (time and place), activity streams, agency (intentions, actions), and structure (normative, authorities, and interpretative). Because these capabilities are continually generated in recurrent action, continuity is achieved and preserved as people interpret and experience their doing as “the same” over time and across contexts. People’s ongoing engagement in social practices and thus their reproduction of the knowing generated in those practices, is how they reconstitute knowledgeability over time and across contexts. Continuity of competence of skillful practice is thus achieved not given. It is a recurrently but nevertheless situated and enacted accomplishment, which cannot simply be presumed.

Orlikowski’s (2002), in adopting the perspective of tacit knowledge as a form of “knowing” inseparable from action (because it is constituted through such action), points upon the need for a complementary view of organizational knowledge. She argues against the conventional distinction used through the general knowledge management literature between tacit and explicit forms of knowledge as it assumes that tacit knowledge is distinct and separable from knowing, and thus action. She further argues that a view of knowing as enacted in practice does not view competence as something to be “transferred”. Thus, the very notion of “best practices” becomes problematic. When practices are defined as the situated recurrent activities of human agents, they cannot simply be spread around as if they were fixed and static objects. Competence generation must be seen as a process of developing people’s capacity to enact what we may term “useful practices”, with usefulness seen to be a necessarily contextual and provisional aspect of situated organizational activity.
The view presented here of knowing in practice depicts knowledge as something very “sticky” and heavily situated, as Brown and Duguid (1998) refer to it, and not easily articulated (if ever possible). We agree with this view, but to further it we also draw upon the work of Wenger (1998). Wenger, in discussing learning communities, sees the knowing in practice as intimately coupled with the process of forming identities that may give information gained within the practice a coherent form of participation. Here, what turns information into knowledge is the way in which it can be integrated within an identity of participating in the practice. If information does not build up to an identity of participation, it remains alien, literal, fragmented, nonnegotiable, and fails to translate into a way of being in the world coherent enough to be enacted in practice. We shall return to the work of Wenger in the next chapter.

3. Social learning

The second strand of thinking that influence our work and further our understanding of knowledge sharing processes and their characteristics from a social perspective is that of Wenger (1998 and 2000) concerning learning communities or social learning systems.

3.1 The rise of communities of practice

Central to this strand of thinking is the concept of communities of practices. It finds its basis in the work of Lave and Wenger’s (1991), and Brown et al. (1989) on situated learning and cognition. Lave and Wenger (1991) observed that a group of people who are doing similar work often takes on the form of what they came to call a “community of practice”. Such communities emerge from the interactions of people within the community, and provide an environment in which situated learning can take place.

3.1.1 Learning within communities of practice

Here, learning is situated in the context in which practice takes place. Traditionally, when we refer to learning we tend to think of classroom settings in school, or training workshops in companies. Such settings are far removed from the practice for which the learning should prepare us. They assume that knowledge may be abstracted from its context, learned in a classroom, and then appropriately applied in the work context. In that same tradition, the emphasis is on learning by the individual, and collaboration between learners is often actively discouraged. Lave and Wenger (1991), and Brown and Duguid (1991) argue that the traditional views on learning and education obscure the fact that an important type of learning occurs naturally, in the everyday activities of people. Such learning takes place in the social, organizational, and physical context in which people work, i.e. situated in a context.

According to Wenger (1998), learning at a social level occurs as a result of the tension between competence and experience. The experience you make in your daily strife is constantly confronted with the competence you uphold as a member of a specific practice. Here competence is seen as being defined historically and socially within that community of members of the practice. To be knowledgeable and to display knowing is a matter of displaying competencies, which are defined within different social communities. Learning is thus seen as interplay between socially defined competence and personal experience drawn in participating within that practice.

Two general overlapping types of learning are distinguishable in relation to a community of practice. The first kind of learning concerns the acceptance of new members into a community, where they acquire the knowledge and skills that make them from novices into experts, newcomers to full-fledged members (Lave and Wenger, 1991). This is a form of individual learning. Here, Lave and Wenger (1991) introduced the concept of “legitimate peripheral participation” in order to better describe it. A potential new member of a community will first do small tasks, where the cost of errors is low. In doing these tasks they start to participate on the periphery. They are not yet full members, having only peripheral legitimacy. As time passes, they are given increasingly more important tasks, and move from the periphery to the core of the community. Even though they initially participate on the periphery, they work within the community, and acquire the knowledge that they need in the situation in which it is needed. As they perform simple tasks, they can observe the expert community members do work that is more complex. By participating in the periphery, they gradually learn the skills, vocabulary, tools, and behaviors that are the standard within the
community. The second type of learning is the learning that takes place at the collective level in the community. Here, the community of practice adapts its structure and set of skills to new situations, where it finds solutions for new problems, and retains those solutions for future use (Wenger, 1998; and Brown and Duguid, 1991).

We view the process of learning as intimately coupled with the process of sharing knowledge. At a social level, learning is not only about reflecting upon the experiences drawn when dealing with problems in the daily work, but also about making sense of phenomena occurring within the practice, aligning your efforts with others, and adopting and applying in to your specific situation the wisdom others share with you. All of these are activities that not only entail sharing of knowledge but also require it.

3.1.2 Characteristics of communities of practice

According to Wenger (1998) three characteristics of communities of practice that make it possible to distinguish them from other collectives. The three characteristics are mutual engagement, joint enterprise, and shared repertoire.

Mutual engagement refers to the interactions between participants in the community, interactions that are necessary to perform the work. Groups of people who have been placed together do not necessarily form a community. It is only when they provide and ask for help, when they socialize, and work together as part of the practice that they can form a community. Mutual engagement is essential for the negotiation of meaning, for making sense of the practice within which the work takes place, and for making sense of the larger environment in which the community exists.

In knowledge work, one of the key reasons for mutual engagement is that each of the members of the community will have knowledge that either needs to be applied in the practice, or that needs to be shared with others in the community. Often, the knowledge needed does not yet exist, and may only be produced by several people working closely together.

Joint enterprise is the collective goal of the community. The enterprise is negotiated by the collective, and changes as the community changes. It emerges from the behavior of the community members. Sometimes the joint enterprise is made explicit, but often it exists only in implicit form, and has to be deduced from the community’s behavior. It will be argued below that communities of practice cannot be designed. At best, they will respond to design. Similarly, joint enterprise cannot be designed, and a community of practice may develop goals that diverge from the organization’s goals.

Shared repertoire is the behavior and habits that have become common in the interactions within the community. According to Wenger (1998) it includes routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions, or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice. The shared repertoire results from the history of a community. It enables the community both effectively and efficiently, to conduct its practices.

The three characteristics or dimensions result from the activities that take place in a community of practice, and in turn can be thought to influence the practice. They will co-occur, but will not always exist to the same extent. For instance, sometimes an extensive shared repertoire may exist, even though a clear joint enterprise is missing. Similarly, a geographically dispersed group may have a joint enterprise and mutual engagement, but may be limited in the development of shared repertoire. A community of practice will display all three characteristics to a large extent.

3.2 Social systems of learning

3.2.1 Constitutive elements

Wenger (2000) defines three constitutive elements of a social system of learning: the community of practice, the boundaries surrounding that practice, and the identities we form in participating in the practice.
Communities of practice

What define a social learning system are of course its members, the individuals belonging to it and participating in its activities, and how they relate to each other. A natural constitutive element of the social learning system is thus a community of practitioners. This is what forms the basic building block and focal point of observation when studying social learning systems. Communities of practice are the containers of social competencies that make up the system. Here the very participation is essential to our learning. It is the very core of what makes us humans being capable of meaningful knowing. Competence is socially defined within the community of practice through the combination of the joint enterprise we engage in, the mutuality (established through the relationships with other members and the establishments of norms and rules dictating those relationships) and the shared repertoire of skills, tools, artifacts and so forth.

Boundaries

However, the communities of practice are not the only building blocks. Another constitutive element is made up of the boundaries of the social learning system. Boundaries of communities of practice are fluid and arise from different enterprise, different ways of engaging with one another, different histories, repertoires, communication modes and capabilities. Boundaries are defined by the tension between competence and personal experience. The phenomena one experiences or deals with when participating in the activities of the community one must be able to relate to the domain of knowledge or competence of the community. The very convergence of competence and experience is important for the existence of a community. Without a core of “truth” with few anomalies, the community will simply not exist. Here one may well compare this to concept of paradigm of Kuhn (1970). But, activities at the boundary are important for the tension that enables learning, shocking one's personal experience so to speak, as it help discover those anomalies and question the wisdom of the community, thus ensuring it's viability and a healthy evolution.

Identities

The last constitutive element of a social learning system is the identities we build or associate with the communities. Wenger (2000, p. 239) expresses it as follows: "In the landscape of communities and boundaries in which we live, we identify with some communities strongly and not at all with others". The adherence to a community and the recognition of its boundaries naturally creates a sense of identity with the community. The physician practicing medicine identifies him-self with professional body of medical practitioners. Knowing, learning and sharing knowledge are not abstract things we do for their own sake. Identity forming and association is here an explanatory factor as it is important to the social learning systems. It combines the competence and experience into a way of knowing, decides what matters and what not, with whom we trust, identify, communicate and share knowledge. Identities become living vessels in which communities and boundaries become realized as an experience of the world. Our ability to deal productively with boundaries depends on our ability to engage and suspend our identities, i.e. looking at the same phenomena in the world from other perspectives. When we have multiple identities, it usually stems from belonging to or associating with other communities.

3.2.2 Modes of belonging

According to Wenger (2000), our belonging to a social learning system can take various forms at various levels of interaction with it. He distinguishes between the following modes of belonging: engagement, imagination, and alignment.

Engagement entails doing things together, talking and producing artifacts. Here, our experience of who we are, is shaped through the engagement in the practice, a sense of identity is established as well as what is doable or not. Imagination involves constructing an image of oneself, of one's communities and of the world in order to orient oneself, to reflect on one's situation and explore possibilities. Alignment involves making sure that our local activities are sufficiently aligned with other processes so that they can be effective beyond our own engagement. This is a mutual process of coordinating perspectives, interpretations and actions to realize higher goals.
Each mode contributes to a different aspect of the formation of social learning systems and personal identities. They coexist in every social learning system to different degrees. In a community such as a nation the participation or belonging to it is more dominated by the mode of imagination as compared to a community of practice, which is more dominated by the mode engagement.

Wenger (1998) further states that the focus on participation in social learning systems has broad implications for what is demanded of us to understand and support learning. For the individuals learning becomes an issue of engaging in and contributing to the practices of their respective communities. For the communities it is an issue of striving to refining their practices and ensuring new generations of members. Finally, for the organizations it becomes a question of maintaining the interconnected communities of practice through which the very same organization know what it knows and thus becomes the rationale for its very existence as an effective valuable organization.

4. Design for emergent knowledge processes

Having now defined our view of knowledge as knowing in practice and looked upon the characteristics of the social processes behind the generation of knowledge (learning) it is time to look upon the third strand of thinking that influence us. This strand concerns the work of Markus et al. (2002) regarding emergent knowledge processes and the design of systems supporting these. What we find important in their work is the motivation behind their attempt and what is demanded in developing a design theory.

Markus et al. (2002) base their work upon the characterization of organizational processes of knowledge work. Knowledge work, unlike service work, defies routinization and requires the use of creativity in order to produce idiosyncratic and esoteric knowledge (Blackler, 1995). This type of work may be described as characterized by variety rather than routine, problematic to describe in manuals, job descriptions and charts (Brown and Duguid, 1991), and professional or technical workers with high level of skill and expertise perform it, e.g., researchers, product developers, advertisers, and consultants.

Knowledge work is thus untidy in comparison with operational or administrative business processes, in which tangible inputs are acted on in some predictable, structured way and converted into outputs. The inputs and outputs of knowledge work, i.e., ideas, interruptions, inspirations, and so on, are often less tangible and discrete, and in knowledge work there are no predetermined task sequences that, if correctly executed, guarantee the desired outcome (Boland and Tenkasi, 1995; and Davenport et al., 1996).

Summarizing the characteristics of a knowledge-intensive work process, Markus et al. (2002, p. 184) define such a process as an “organizational activity pattern characterized by (1) an emergent process of deliberations with no best structure or sequence, (2) an actor set that is unpredictable in terms of job roles or prior knowledge, and (3) knowledge requirements for general and specific distributed expertise”.

In recognition that emergent knowledge processes differ qualitatively from semi-structured decision making processes, Markus et al. (2002) argue that existing types of systems and their associated design theories do not adequately serve the unique requirements of this class of design situations. More specifically, they assert that the development literature on decision support systems, executive information systems, expert systems, organizational communication systems, organizational knowledge repository systems, and organizational memory systems does not provide sufficient guidance for how to build systems that support emergent knowledge processes.

According to Markus et al. (2002), the poor fit between the requirements of such work processes and existing IS design theories stems from three disconnects. First, decision-making in emergent knowledge processes requires that expert knowledge needs to be adapted or contextualized to specific local conditions. Intended to support semi-structured decision-making, decision support systems and executive information systems do not provide system features handling expert knowledge and contextualizing translation rules. Resulting from this, these types of systems inhibit creative problem finding and solution generation. While expert systems manage general expert knowledge, they fail to support contextual knowledge and the flexibility needed for process emergence. Second, decision support systems, executive information systems,
expert systems, and organizational memory systems are all specifically designed for a known type of user. Being designed for a particular type of user community, these systems are not well adapted to emergent knowledge processes characterized by shifting user types having varying knowledge requirements. Third, today knowledge workers have access to many different types of knowledge management support such as decision support systems, expert systems, executive information systems, organizational communication systems, and organizational knowledge repositories. The problem is that there are too many isolated systems. Because the systems are not integrated into the work practice, knowledge workers tend to manage their systems rather than getting the job done. Because the systems are not integrated with one another, there is a risk that knowledge workers do not use an important system like, for instance, a knowledge repository.

Building on these three disconnects, Markus et al. (2002) argue that a new IS design theory for systems supporting emergent knowledge processes is needed, one that provides a set of general principles to solve a class of business problems, rather than a unique set of system features to solve a unique business problem. As basis for developing a design theory, in assisting system developers in their efforts to design effective emergent knowledge processes support systems, they turn towards the work of Walls et al. (1992) concerning design theory for vigilant EIS. Here, as interpreted by Markus et al. (2002), any IS design theory must consist of three sets of interrelated elements. First, it must provide us with a set of user requirements derived from kernel theory. Then, it must provide us with principles for governing the actual development process. Finally, it must provide us with principles governing the design of the system, i.e. specifying and implementing its features.

The design theory developed by Markus et al. (2002) matches the principles guiding the selection of system features and principles guiding the actual development process with the unique user requirements for IT support and characteristics of emergent knowledge processes. Here, the characteristics of emergent knowledge processes serve as their kernel theory. The set of principles for guiding IS design they present is, however, not divided into those two set of principles of above. Rather, as they state, borrowing support from Walls et al. (1992), when designing systems support emerging knowledge processes these sets of principles become inextricably intertwined, something which is notable in their presentation of design principles.

However, the work of Markus et al. (2002), although elegantly demonstrating the need for design guidelines concerning support systems targeted for knowledge processes (something we profoundly agree with), is still, to us, found wanting. They base their design principles upon a “kernel theory” claiming to define characteristics and requirements of “emergent knowledge processes”. Here, they hope to in the tradition of Keen and Scott Morton (1978) make a contribution to the IS field. Looking into the theoretical background behind the concept we find not one but several different authors touching upon a wide range of organizational issues concerning knowledge work. However, none of them seems to approach processes of knowledge sharing from either a social or a “knowing-in-practice” perspective. Looking into their design principles, they also seem to guide the development of system supporting processes on an organizational level, not on a social level. For these reasons we do not find their principles specific enough, i.e. they are too general in character for us. Thus, we return once again, in the next chapter, to the work of Wenger (1998), but this time now focusing upon that which concerns the design for learning (and knowledge sharing).

5. Design for learning

"Learning cannot be designed: it can only be designed for – that is, facilitated or frustrated". (Wenger, 1998, p. 229)

If we cannot design, in a traditional sense, for learning, and hence knowledge sharing in a social context, then we disqualify most design attempt since it becomes impossible to make any specifications. Systems may be designed, but the practice, which we wish to support, is a response to design. How, then, are we to go about in getting directions as to what to design, i.e. facilitate knowledge sharing and learning? In this regard, Wenger (1998) provides us with a possible roadmap to follow.

Wenger’s (1998) view of design is that of a systematic, planned, and reflexive colonization of time and space in the service of an undertaking. His perspective includes not only the production of artifacts, but also
the design of social processes such as organizations or instructions. In drawing a roadmap to follow, he begins by describing those dimension, which defines the space wherein the design undertaking resides. He continues by defining an infrastructure for learning and what elements it contains. Finally, in putting together a greater picture, he defines a framework for a learning architecture that may be use to question how our design addresses the different requirements of a learning architecture.

5.1 Dimensions of design
To Wenger (1998), design is an issue of balancing different dimensions of a learning architecture, which facilities, in enabling or supporting our belonging to a social learning system, should address. Four dimensions emerge here that are important and affect the design of social learning systems.

The first dimension is one concerning participation vs. reification within the practice. Participation within the practice entails allowing new members to enter either through legitimate peripheral participation (Lave and Wenger, 1991) or through multi-membership with different communities. It also entails ensuring possibilities for working together and establishing joint ventures. Reification deals with the formation of shared repertoire, common language, and community memory and so forth. Wenger (1998) places strong emphasis to the negotiating of meaning within social learning systems and the activities of participation and reification are two cornerstones in that process.

The second dimension concerns the balance between the designed and the emergent within the practice, allowing for new structures to emerge as the practice moves forward and providing fixed structures in ensuring continuity, i.e. flexibility vs. rigidity.

The third dimension concerns the local and the global, connecting the practice with the outer world or a larger context. It concerns, for instance, how to move locally generated, highly situated, knowledge out of the practice and allowing it to have effect elsewhere within the organization. It also concerns how the endeavors of the practice are aligned with the rest of the organization and so forth.

The fourth dimension concerns possibilities of identification with and negotiability within the practice. Here, design creates areas of identification where economies of meaning may be negotiated. It addresses the issues of participation and non-participation of the practice and establishes or questions the owner-ship of the negotiated meaning within the practice. In addressing these above dimension of design, a learning architecture or infrastructure must offer facilities for each of the modes of belonging. We will return to these dimensions later and both discuss and elaborate them further.

5.2 Infrastructure of learning
Wenger (1998) points out that an infrastructure for knowledge sharing and learning should give hints or provide directions as to what facilitates are necessary in order to ensure a balance of the modes within the practice. It should, in enabling our engagement within the practice, address facilities that ensure continuity and mutuality as well as contributing to and maintaining the core competence. This mode of belonging is one of community building and of establishing a shared repertoire. It should also for the mode of imagination ensure facilities are provided for in allowing learning to encompass and deal with the broader context, to orient ourselves, reflect upon our achievements, and explore new avenues. Finally, through the mode of alignment we make sure that whatever we contribute with will have effects to tasks defined beyond our immediate engagement. Facilities should here be provided in order to support activities of convergence and coordination, as well as setting up of legal boundaries (arbitration).

According to Wenger (1998), the modes of belonging to a social learning system do not work in solitude alone but also in concert. It is in combining the modes of belonging that we can form learning-communities that exhibit specific characteristics of their practices. The combination of both engagement and imagination brings about a reflective practice. They combine the ability to both engage oneself in and to distance from the practice. The reflective side of the practice is important since without reflection there is no learning. You just cannot learn from the experience gained in action alone, only instrumental reactions as in the case of Pavlov's dogs. The combination of imagination and alignment provide us with the ability to act with respect
to a broad and rich picture of the world. We become able to relate better to a broader context, align our activities with others and understand why. Through the combination of the modes of engagement, in providing common language, and alignment, in providing coordination, we become able to better bring together different perspectives of the world and create shared/mutual meaning.

5.3 Framework for a learning architecture

By combining the different modes of belonging to a social learning system (engagement, imagination, and alignment) with the dimensions of design Wenger (1998) provides us with a framework for a learning architecture, see table 1 below.

<table>
<thead>
<tr>
<th>Partipation/Reification</th>
<th>Engagement</th>
<th>Imagination</th>
<th>Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Combining them meaningfully in actions, interactions and the creations of shared histories</td>
<td>Stories, playing with forms, recombination, assumptions</td>
<td>Styles and discourses</td>
</tr>
<tr>
<td>Designed/Emergent</td>
<td>Situated improvisation within a regime of accountability</td>
<td>Scenarios, possible worlds, simulations perceiving new broad patterns</td>
<td>Communication, feedback, coordination, renegotiations, realignment</td>
</tr>
<tr>
<td>Local/Global</td>
<td>Multi-membership, brokering, peripherality, conversations</td>
<td>Model, maps, representations, visits, tours</td>
<td>Standards, shared infrastructures, centers of authority</td>
</tr>
<tr>
<td>Identification/Negotiability</td>
<td>Mutuality through shared action, situated negotiating, marginalization</td>
<td>New trajectories, empathy, stereotypes, explanations</td>
<td>Inspiration, fields of influence, reciprocity of power relations</td>
</tr>
</tbody>
</table>

Table 1. Articulating components and dimensions (Wenger, 1998, p. 240).

The purpose of using this framework of a learning architecture is not to provide a new classification system for existing facilities, or to ask how a specific design serves the different requirements of the learning architecture. No, given a spatial arrangement, a network system, or a curriculum, the idea is to be able to ask how such a design addresses the different dimensions of the framework and provides facilities that support the different modes of belonging. As the modes works in combination the challenge is to enable a balance between them. Especially without letting the need for one be fulfilled at the expense of the others.

In this regard, the framework may be used for questioning not only how but what one has provided in terms of facilities or functionality of the intended support system. This, not only for supporting or enabling the different modes of belonging to a social system, but also in enabling the formation of learning communities through the combining of them. Here, in accordance with the goals of the activities within the organizational process and the aims of the intended support system, one may question what support is to be provided in enabling, for instance, a reflective practice, the ability to act with respect to a broad and rich picture of the world, and the ability to coordinate various perspectives in ensuring shared meaning.

6. The practice of vulnerability analysis

6.1 Introduction to and aim of the project

The purpose of the project was to develop a system that supports security specialists within a large telecommunications company in their daily work of vulnerability analyses of different plants, which the company operates and maintains. A plant, in this regard, may be, for instance, a telephone station or a computer system. Towards such an “object”, there exists a certain threat scenario. This scenario contains all the threats that may be targeted at or affect an object and its parts or components. It may contain both the threat of fire in the station as well as flooding. In order to ensure some protection here different countermeasures are demanded in order to counteract or reduce the effect of the different consequences once the threats are realized. If a threat is realized it brings about a cost, partly for loss of component in object and partly for restoring it. The vulnerability analyses aim to prevent or reduce the effects of a threat of being realized, leading to damage of a plant (or an object).
All of these possible types of threats demand counter measures. These must be balanced in order to become economically justifiable. It may be fully acceptable with a measurement package (suit of counter measures) that is not as effective in countering all of the possible and probable threats. Especially if the “unaccounted” threats have a low frequency or the cost associated with the damage is very small. Vulnerability analysis work aims to ensure as a long life span as possible of the plants (or objects) of the company, thereby maximizing the revenue associated with them. It also aims to ensure appropriate protection exits for threats that may be damaging to the business activities at large.

The aim of the development project, in this context, was to provide the users, the security specialists, with a support tool for managing the complexity in analysis work by making visible and documenting the analysis work, i.e. serve as a help in organizing information during security analysis work. The support tool provided for the capability of simulating and testing different possible solutions, in resolving a threat scenario, thus making visible how the costs associated with the different measures evolves. The support tool also aimed to function as a knowledge base for the security specialists for drawing upon experiences made with previous similar problem situations. Here was sought support for retrieving suggestions for actions and measures by reusing solutions to problem situations which have been found to be either general in application or proven to have characteristics that have rendered them successful. Further, the support tool serves as a means for furthering discussion, and exchange of ideas, insights and experiences amongst the users by allowing the captured and represented analysis work to be communicated with each other through a common platform or interface, i.e. the system in itself. In this regard the support tool came to serve as a means for promoting both knowledge sharing and learning within the user community.

6.2 Capturing and characterizing the practice

6.2.1 Characteristics of the practice

The process vulnerability analysis and the practice of security analysts is indeed easily characterized as one entailing knowledge intensive work, highly innovative and analytical, exhibiting a high degree of interaction, formal as well as informal interactions between peers. To characterize the process as an "emergent knowledge process", using the concept of Markus et al. (2002), would be to say too much. It is not a process of unstructured patterns of organizational activities. The process of vulnerability analysis has indeed a clearly defined goal (that would obvious we hope from earlier discussion), and requires some specific definable skills and competence (such as, for instance, a set of methods and skills of using them). It is neither an emergent process but a clearly sanctioned organizational process "suffering" some form of budget. However, the art and practice of vulnerability analysis that the development project aims to support is indeed one of knowledge intensive work. Activities of knowledge sharing and learning (knowledge creation) within these processes are heavily situated in the work practice. The group or community of security analysts, within their practice, is indeed a good example of a social learning system such as defined by Wenger (1998), and through their belonging to it, they come to form a learning community. Here, as a community they exhibit the same characteristics (mutual engagement, joint enterprise, and shared repertoire), as defined by Wenger earlier, that makes it possible to distinguish them from other constellations within the organization.

The practice of vulnerability analysis may be broken down into the following four "knowledge" activities or modes: capture, organize, reflect, and communicate. These represent the transformation from thought/idea to report/product, see figure 1.
During vulnerability analysis work, the security experts document every step and action they take in arriving at the final report, i.e. the document containing recommendations and conclusions. This entails capturing the information relevant to the problem situation, i.e. analysis situation, at hand, and representing it. Most of the information is captured through the use of different models and concepts that represent, to the users, the "reality" of their practice, such as the relationships between different components of a plant and values, as an example see figure 2.

![Fig. 2. The basic model of relationships between measures, threats, and objects, together with their respective values.]

An activity that is closely related to capturing is the organizing the information or knowledge arrived at during the previous mode. Here organizing is one of creating relations between different information pieces, for example finding relevant relations between components of a plant and threat scenario. Organizing is also an act of decomposition, for example breaking down a complex threat scenario into components that are more manageable and may be given individual values. It is also an act of creating hierarchies of different components, for example creating measurement packages, building a threat scenario, or organizing plants into groups describing how they are related to each other.

The practice of vulnerability analysis is also one of reflecting upon what is captured and structured of the problem situation. Here, reflection is achieved by several means. First, by gradually giving informational pieces of the analysis some form of structure, see figure 1, it is possible to make simulations of different solutions. Thus, it becomes possible to make visible how values may change as different configurations of relationships and components are tried out. Second, by reusing earlier solutions that has proven useful in some general way and applying them to the current analysis situation.

The art of vulnerability analysis is also one of communicating. It is not only the report at the end of the process that is communicated to the "outside world", but communication is also the exchanging of ideas and experiences within the community. Here it takes the form of allowing insight into each other's work and furthering the opportunities of working together, as well as creating shared resources that may be reused.

One might find other concepts besides the ones above that perhaps may be used to describe the knowledge activities of the vulnerability analysis process. However, the ones we have arrived at represent how we came to view how the processes of knowledge sharing and learning were instantiated in the practice. Here, learning within a social context is achieved by constructing shared concepts and models, upholding common language and assumptions that provides the structure for capturing the "tacitness" of the practice, i.e. mastering the complexities. This however is just one side of the coin. On the other side, we find the act of reflecting upon this structure and sharing your insights and experiences with others within the community.

### 6.2.2 The development of the support tool

The support tool was developed using experimental methodology through a series of interview sessions with a group of security specialists, i.e. the potential users. The whole development process took about two years.

In order to document the work practice underlying their work, they were asked what type of information they needed in order to perform their tasks and how they structured it to get a feel of the different problems at hand. For each interview session, the support tool was continually developed and incrementally enhanced in order to give the users the ability to get a feel of the tool and the possibility to put us on the right track so to speak. In a sense, we, the developers, became the narrators of the story told by the users. The support tool was also developed further on the initiative of the developers in order to point upon possible capabilities.
For the actual development of the system, no specific approach was followed. The issues we dealt with were found to be too soft and difficult to capture with a "traditional school book" method as analysis work involves a lot of tacit knowing, most embedded in hidden assumptions and unarticulated "ways of going about". Here, we had to follow some form of naive approach that grew out of the necessity for both approaching and capturing their work practice through some form of learning process. Thus, the development process became one of incrementally refining and enlarging the support tool. This allowed the developers to learn about and get familiar with the work practice, the language used, the mind set of the users (how to think about and relate to different objects and issues), and so forth, and most importantly allowed us to discover possibilities with the support tool and point upon different capabilities. However, it also allowed the users to reflect upon their own work, question assumptions, and providing a means for capturing and expressing tacit knowledge.

Out this learning process grew concepts, models (see figure 2), and a gradual structuring of the stored information that provided not only the focus of the development but also a common language. Far more concepts and models were generated than actually implemented into the tool. Only the ones that had any real practical use survived. However, the generation of these measurements helped us developers understand what and how the users talked about and what they meant. These helped us developers in mastering a complex situation and at the same time they became a vehicle for formalizing some of the “tacitness” in the work practice that otherwise would have been hidden in the assumptions the users had of their work.

In order to support the users in the documenting of their work process and capture related information the system support the representation of these in the form of unstructured texts in natural language, i.e. the technical jargon of their practice. Thus, it preserves the common language instead of hampering the users with an artificial vocabulary for representing their work. In order to capture the relationship between pieces of information that the users create all information is stored in some form of a hypertext structure. This allowed for dynamically changing the structure of the captured information as new insights were gained. The possibility of the unstructured text, in offering rich descriptions for communicating vaguely formulated as well as clearly expressed thoughts and concepts, not only rendered it as the most interesting means of representing the user knowledge but, to us, the only means that could fairly preserve the integrity and original intentions of the users and their work practice.

In sum the following principles were followed:

- We used natural language in capturing information and intentions of the practice; providing support for the activity of capture.
- We used hypertext structure in representing relations between “objects” within the system; providing support for the activity of organizing and flexibility.
- We used simple and generic concepts in reifying common assumptions, providing focus and shared language; thus providing support for all of the knowledge activities.
- We used weakly structured representation of information, based on the concepts in order to provide for simulations and calculations, yielding different perspectives; providing support for the activity of reflection.
- We developed the support tool incrementally with strong user interaction, letting them drive the development as they gradually came to articulate more and more aspects of their “world”; thus providing for some form of learning process within the development process for them.
- We approached the practice and the development situation from learning perspective, where we the developers were socialized into the practice of vulnerability analysis; thus providing for some form of learning process within the development process for us.

7. Lessons learned

The development of the support system was indeed a time consuming feat, and the lessons we drew when dealing with issues of sharing knowledge rooted in the practice reflect this. We discovered early on in the project that users had a hard time of articulating their worldview to us, the developers, in terms that we understood. Much of the skills and understanding of their work lay hidden, unconsciously, deeply rooted in
the practice. In order to gain insight into their work we had to be socialized into their world, i.e. form an identity with their practice that allowed for multi-membership (Wenger, 1998), both with the community of security specialists and with the one of IS-developers. The journey undertaken into this world was one that Lave and Wenger (1991) would characterize as “legitimate peripheral learning”. We, the developers, had to become that “boundary spanning object” (Wenger, 2000) that allowed the wisdom of the security specialist community pass into the sphere of IS development, something which can’t happen if you’re not part of the practice and at least partly “own” its jargon. This is one reason for the long development time and an important lesson to draw that is in line with social theory of learning concerning individual learning.

The strong user interaction with frequent meetings was necessary in order to keep the process alive and provide a learning process for the community members as well. In providing means for the users to express themselves, we developed the support system incrementally beginning with the simplest concept of the practice. This is in line with the ideas of Sundgren (1995). In discussing design principles for information systems with partially unknown needs he defines three different categories within these may fall. One them concern the usage of basics concept of the object system associated with the information system to be designed. This approach provides a flexible system in situation where it has been difficult for some reason or other to come up with precise specifications of information needs to be satisfied by the information system. Sundgren points out that concepts, particularly fundamental concepts, tend to change rather slowly in spite of a dynamic business environment. Here these concepts, on a basic level come to provide the focal point for articulating tacit knowledge, as Polanyi (1967) would agree. Following a conceptual modeling approach may here, according to Sundgren, provide with a common description model in ordinary language of the practice, a common professional language in preserving the jargon of the practice, or a formalized conceptual model which may be understood and used both by the professional s and the system involved in the practice. This approach was necessary in supporting the shared repertoire within the practice and facilitating for mutual engagement as well as guaranteeing possibilities for joint venture of the members. These are all all important characteristics of a community practice (Wenger, 1998).

The lessons learn from the development of the support, presented in the previous chapter, all, more or less, relate to how we approached the actual development process in capturing that elusive knowing in practice. In relating the lessons learnt to the work of Wenger (1998) we find that the social theory of learning do provide us with explanatory power, as discussed above. Therefore, it seems to us that this theory, undoubtedly, may make an important contribution as a kernel theory underpinning design principles guiding the development process.

However, a design theory should also, as Markus et al. (2002) point out, guide us regarding the facilities of the target system. Interesting here is whether social theory of learning may provide us with directions here as well. Here, Wenger (1998) points out that the different modes of belonging to a social learning system are all important ingredients of learning as they anchor it in practice yet make it broad, creative, and effective in the world. In addressing the dimensions of design, an infrastructure of learning must offer facilities for each of the modes of belonging to a social learning system. He specifically emphasizes that it is by combining these modes specific qualities of the practice are enabled in creating a richer context for knowledge sharing and learning. Therefore, we find it only logical that principles guiding the design of an infrastructure for learning should at least seek to provide facilities for those modes of belonging that allow the qualities to emerge that we seek to uphold within practice. This is where we will pick up the threads and continue with further exploration and analysis in future work.

8. References

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