Knowledge management: a personal knowledge network perspective

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Abstract

Purpose – *This article aims to introduce the personal knowledge network (PKN) model as an alternative model to knowledge management (KM) and to discuss whether personal knowledge management (PKM) is better adapted to the demands of the new knowledge environments. The PKN model views knowledge as a personal network and represents a knowledge ecological approach to KM.*

Design/methodology/approach – *KM and PKM have attracted attention over the past two decades and are considered as important means to increase organizational and individual performance. In this article, the author reviews previous models of KM and PKM and explores their failure to address the problem of knowledge worker performance and to cope with the constant change and critical challenges of the new knowledge era. The author further highlights the crucial need for new KM models that have the potential to overcome the shortcomings of previous models. In light of these shortcomings, the article introduces and discusses the PKN model as an alternative model to KM and PKM that is better adapted to the demands of the new knowledge environments.*

Findings – *Unlike traditional KM/PKM models which view knowledge as a thing or process, the PKN model views knowledge as a personal network and represents a knowledge ecological approach to KM.*

Originality/value – *The article focuses on personal knowledge and the links to networks and knowledge ecologies in an innovative way for consideration within KM.*

Keywords *Knowledge management, Personal knowledge management, Organizational learning, Personal knowledge network, Knowledge ecology, Personalization*

Paper type *Research paper*

1. Introduction

Since its introduction in the early 1990s, Knowledge Management (KM) has approached the challenge of increasing knowledge worker productivity and achieving organizational competitive advantage. Over the last two decades, the expectations have been that KM would be able to improve growth and innovation in organizations, productivity and efficiency, customer relationships, employee learning, satisfaction and retention, and management decision-making. Despite isolated achievements, KM, however, has not demonstrated a big competitive advantage to the organizations that have invested in it and most of the KM initiatives have failed (Davenport *et al.*, 2008; Malhotra, 2004; McAfee, 2006; Nonaka *et al.*, 2000; Pollard, 2003; Wilson, 2002).

In response, in recent years, the importance of personal knowledge has been highlighted in various works and the interest in the topic of personal knowledge management (PKM) has steadily increased (Efimova, 2005; Grundspenkis, 2007; Jarche, 2010; Pauleen and Gorman, 2011; Pollard, 2008; Smedley, 2009, Wright, 2005). However, little significant conceptual work around PKM has been undertaken. In fact, most of the PKM models proposed in the literature lack a theoretical framework, thus hindering them from being more widely understood and adopted. Moreover, the existing PKM models do not address the relationship between personal knowledge management (PKM) and organizational knowledge management (OKM) (Gorman and Pauleen, 2011).

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Hence, we need to rethink how we design new theoretically sound KM models that can respond to the learning demands of the twenty-first century. The new knowledge era is defined by rapid knowledge development. ''It is the nature of knowledge'', Drucker (1992) stresses, ''that it changes fast and that today's certainties always become tomorrow's absurdities'' (p. 95). As a consequence, there is a crucial need for new KM models to meet the challenges of rapidly changing knowledge and increasingly complex work and learning environments.

In this contribution, we take the challenge of investigating the flaws of traditional KM and PKM models; thereafter we develop the PKN model as a new vision of KM towards a new model of personalized and networked KM characterized by the continuous creation of personal knowledge networks (PKN) within open, emergent, and self-organized knowledge ecologies. In the PKN model, personal and organizational KM converge around a knowledge worker-centric work and learning environment.

2. Knowledge management

Knowledge management (KM) is a term that has been surrounded by a lot of controversy and confusion ever since its introduction in the early 1990s. KM is hard to define in a precise way. In the KM literature, there are many definitions and interpretations of the term KM, pointing to different perspectives and models. Despite lack of agreement on what is meant by KM, definitions of KM revolve around two core views of knowledge:

1. Knowledge as a thing.
2. Knowledge as a process.

2.1 Knowledge as a thing

Early KM models in the early 1990s shared common emphasis on a static view of knowledge. The knowledge-as-a-thing-driven KM model focuses on the technology-based, predefined representation of knowledge. This model adopts the view of knowledge as an object that can be captured, stored and reused. Thereby, KM is often perceived as merely a technological solution, consequently a significant amount of attention is placed on implementing platforms and repositories to capture, store, control, manage and reuse structured knowledge. Table I lists some KM definitions, which adopt the view of knowledge as a thing.

2.2 Knowledge as a process

The more recent KM literature stresses the importance of the people side of KM and acknowledges the input of individuals in making KM effective (cf. Akamavi and Kimble, 2005; Davenport and Prusak, 1998; Davenport and Völpel, 2001; Malhotra, 2004; McDermott, 1999; Nonaka and Takeuchi, 2005; Wilson, 2002). In contrast to the static and predefined representation of knowledge, this literature focuses more on the dynamic representation of knowledge. Most of the same literature, however, shares the view according to which knowledge is regarded as a process. Almost all this literature includes references to a common set of processes and activities with respect to knowledge. These include: acquisition, creation, development, dissemination, transfer, sharing, and application. Furthermore, this literature often concentrates on the notion of the duality of knowledge, e.g. tacit vs explicit (Nonaka and Takeuchi, 2005), participation vs reification (Wenger, 1998) and moves the focus to the distinction and conversion between tacit and explicit knowledge. A sample list of KM definitions which adopt the view of knowledge as a process is provided in Table II.

The class of knowledge-as-a-process-driven KM models is best represented by the Nonaka and Takeuchi's knowledge creation process, which has had a profound impact on many involved in the field of KM. Nonaka and Takeuchi (2005) adopt a dynamic model of KM, view knowledge as a flow rather than object and focus on knowledge creation, collaboration and practice as opposed to KM. According to Nonaka and Takeuchi, knowledge creation is a spiraling process of interactions between tacit and explicit knowledge. This knowledge creation model has been referred to as the SECI model, which encompasses four different

Table I KM definitions: knowledge as a thing

Author	*KM definition*
Davenport and Prusak, 1998	Knowledge management is getting the right information to the right people at the right time
Ives *et al.*, 1997	Knowledge management, in its most current sense, may generally be thought of as the effort to make the knowledge of an organization available to those within the organization who need it, where they need it, when they need it, and in the form in which they need it
Rosenberg, 2006	Knowledge management is the creation, archiving, and sharing of valued information, expertise, and insight within and across communities of people and organizations with similar interests and needs, the goal of which is to build competitive advantage
Wiig, 1997	KM is to understand, focus on, and manage systematic, explicit, and deliberate knowledge building, renewal, and application
Bair and O'Connor, 1998	KM technology is the integration of families of software products, including information retrieval, groupware and document management
Coulson-Thomas, 1997	Knowledge management has become a question of access to particular forms of knowledge, especially data and information, that are held electronically or stored in defined places
Bair, 1997	Knowledge management aims to capture the knowledge that employees really need in a central repository and filter out the surplus
Fenn, 1996 (cited in Morey, 2001)	Knowledge management promotes an integrated approach to identifying, capturing, retrieving, and evaluating an enterprise's information assets. These information assets may include databases, documents, policies, procedures, as well as the uncaptured tacit expertise and experience stored in individual's heads

modes of knowledge creation, namely: *S*ocialization, *E*xternalization, *C*ombination, and *I*nternalization (Nonaka and Konno, 1998):

1. *From tacit to tacit, through socialization*: Socialization is the process of sharing tacit knowledge not through language but through observation, imitation, and practice. The socialization mode starts with building a ''place'' or ''context'' of social interaction.
2. *From tacit to explicit, through externalization*: Externalization is a process of articulating tacit knowledge into explicit concepts. It is generally based on metaphors, analogies, concepts, hypotheses, and models.
3. *From explicit to explicit, through combination*: Combination is the process of systematizing concepts into a knowledge system, and it integrates different bodies of explicit knowledge. Once knowledge is captured, it becomes explicit knowledge i.e. information that can be stored and accessed. During the combination process, reconfiguration of existing explicit knowledge through sorting, adding, reorganizing, and combining can lead to new knowledge.
4. *From explicit to tacit, through internalization*: Internalization is the process of embodying explicit knowledge into tacit knowledge. Explicit knowledge is internalized into individual's tacit knowledge bases in the form of mental models or technical knowhow.

Nonaka and Konno (1998) further introduce the concept of *ba*, as a shared space or context for emerging relationships that serves as a foundation for knowledge creation. ''Each *ba* offers a context for a specific step in the knowledge-creating process'' (Nonaka *et al.*, 2000, p. 16). Socialization occurs in *originating ba*, where experiencing and empathizing activities are supported by network building tools. Externalization occurs in *dialoguing ba*, where

Table II KM definitions: knowledge as a process

Author	*KM definition*
Nonaka and Takeuchi, 2005	Our dynamic model of knowledge creation is anchored to a critical assumption that human knowledge is created and expanded through social interaction between tacit knowledge and explicit knowledge. We call this interaction knowledge conversion
Malhotra, 2000	Knowledge management includes various processes such as acquisition, creation, renewal, archival, dissemination, and application (conversion of new knowledge into action or behavior modification) of knowledge
Malhotra, 1998	Essentially, it embodies organizational processes that seek synergetic combination of data and information-processing capacity of information technologies, and the creative and innovative capacity of human beings
Alavi and Leidner, 2001	KM is largely regarded as a process involving various activities [. . .] At a minimum, one considers the four basic processes of creating, storing/retrieving, transferring, and applying knowledge
Angus *et al.*, 1998	knowledge management is the concept under which information is turned into actionable knowledge and made available effortlessly in a usable form to the people who can apply it
Davenport *et al.*, 2008	We define knowledge management as a concerted effort to improve how knowledge is created, delivered and used
Gorelick *et al.*, 2004	Knowledge management is a framework for applying structures and processes at the individual, group, team, and organizational levels so that the organization can learn from what it knows (and acquire new knowledge if required) to create value for its customers and communities. The knowledge management framework integrates people, processes, and technology to ensure performance and learning for sustainable growth
Knapp, 1998	KM is a set of processes for transferring intellectual capital to value-processes such as innovation and knowledge creation and knowledge acquisition, organization, application, sharing, and replenishment

articulating and conceptualizing activities are promoted by discussion supporting tools. Combination occurs in *systemizing ba*, where connecting and combining explicit knowledge are supported by knowledge dissemination tools. Internalization occurs in *exercising ba*, where reflecting and embodying explicit knowledge are supported by reflective analysis tools (Nonaka *et al.*, 2000; Nonaka and Konno, 1998).

3. Deficiencies in traditional KM Approaches

There is a wide agreement that most KM efforts have failed to address the challenge of increasing knowledge worker productivity (Davenport *et al.*, 2008; Malhotra, 2004; McAfee, 2006; Nonaka *et al.*, 2000; Pollard, 2003; Wilson, 2002). Such failures basically result from the practice to see KM mainly as a technology issue (Davenport *et al.*, 2008; Delmonte and Aronson, 2004; Malhotra, 2005) and the heavy emphasis on knowledge as a thing and/or process.

3.1 Knowledge as a thing

In a knowledge-as-a-thing-driven KM model, knowledge is assimilated to objects (Nabeth *et al.*, 2002) and KM systems are not really managing knowledge but information and a large part of what is presented as being KM is often simply information management under a new label (Hildreth and Kimble, 2002; Kimble *et al.*, 2001; Malhotra, 2005; Wilson, 2002). Information is explicit knowledge that is easily expressed, captured, stored, and reused. In

the KM literature, there is wide recognition that explicit knowledge represents only the tip of the iceberg. Only a small fraction of valuable knowledge is explicit and there is a huge mass of high-quality knowledge embedded in people, which is not easily expressible and cannot be recorded in a codified form. Additionally, many companies are discovering that the real gold in KM is not in building platforms, distributing documents or combining repositories, but in sharing ideas and insights that are not documented and hard to articulate (McDermott, 2001). This undocumented, hard-to-articulate knowledge is what has been called tacit knowledge (Polanyi, 1966). For Polanyi, ''we can know more than we can tell'' (p. 4). Likewise, Drucker (1969) disputes the notion that tacit knowledge can be managed. Nonaka and Takeuchi (2005) also point out that tacit knowledge differs from information in that it resides in people and can thus only be created, sustained, emerged, and shared through socialization. And, Wenger (1998) stresses that information stored in explicit ways is only a small part of the picture. In Wenger's words: ''it is not possible to make everything explicit and thus get rid of the tacit [. . .] It is possible only to change their relation'' (p. 67).

Even capturing knowledge that may be expressed, codified and stored is not without its problems. Capturing knowledge in a codified form is time and effort consuming. Additionally, knowledge can be isolated from its context and it can rapidly become out-of-date, obsolete and useless. Busy knowledge workers have often been asked to make explicit the implicit knowledge that guides their daily work. They have to interrupt their work and try instead to get familiar with a central, feature-rich and often difficult to use KM system and then focus on how to use a given template for example, to write a report or classify a document. Often, a knowledge worker does not have the willingness to do this extra job. And, if she is willing to take the time to capture her knowledge, the result will likely be static documents that are general, incomplete, and out-of-context. In the KM literature, it has already been pointed out that knowledge is context sensitive. Codification of knowledge in the form of information tends to abstract knowledge from the context in which it acquires its specific meaning and that provides the common ground for understanding between individuals (Devlin, 1991). It is quite possible to have knowledge that makes sense and is useful in one context, and makes no sense at all and is utterly useless in another (Mackenzie Owen, 2001). Snowden (2002) also stresses that knowledge is deeply contextual and writes ''We only know what we know when we need to know it'' (p. 102). And, Nonaka and Konno (1998) point out that ''knowledge is embedded in ba'' (p. 40); i.e. the shared space or context. ''If knowledge is separated from ba, it turns into information'' (p. 41).

3.2 Knowledge as a process

The knowledge-as-a-process-driven KM model has its primary focus on the automation of the processes of:

- Archiving best practices and past success stories to guide future decisions and actions.
- Knowledge creation.

The view of knowledge as a process and the focus on best practices and the automation of knowledge creation processes conflict with the nature of knowledge. Best practices capture yesterday's knowledge. Pollard (2003), for instance, states that, ''every job today, every process, is unique and therefore, the expectation that KM systems could capture best practices, success stories and lessons learnt that could be reapplied by others again and again was unrealistic'' (para 6). In the same direction, Siemens (2006) stresses that yesterday's solutions do not always work today and notes ''Knowledge is changing. It develops faster [and] it changes more quickly [. . .] Over the last several decades, more of our knowledge has shifted to soft knowledge. When things change rapidly, many knowledge elements do not have time to harden before they are replaced or amended'' (p. 18).

The automation of the knowledge creation process also fails to address the complex and uncertain dimensions of knowledge. The knowledge creation process cannot be reduced to a string of predetermined processes. It rather emerges through a series of processes that cannot be predicted or anticipated. This explains why different KM authors and theorists define and explain knowledge creation processes differently (see Bereiter, 2002; Engeström,

1999; Nonaka and Takeuchi, 2005). Nonaka and Takeuchi (2005), for instance, see knowledge creation as a spiral of socialization-externalization-combination-internalization. The SECI model, however, represents only four different processes that a knowledge creation process can be in, and misses other processes crucial for knowledge creation, such as the processes of error detection and correction. Moreover, the SECI model is a clear view of knowledge creation as a linear process. The linearity of the SECI model is not well adjusted to describing what is actually going on in knowledge creation. In each new context, knowledge creation is a unique process and is the result of emergent processes that do not follow any particular order. Nonaka *et al.* (2000) acknowledge this problem when they describe the knowledge creating process as a collection of intertwined SECI spirals of various sizes that interact with each other.

4. Need for new KM models

Obviously, traditional KM models have failed to cope with the increasing complexity and fast-paced change of the new knowledge environments. To summarize, the failures mainly result from the view of knowledge as a thing or process and the heavy emphasis on technology. Knowledge is, however, more than static content or predetermined process, and technology is just an enabler. In order to reflect the nature of knowledge and align with the rapid change of the new knowledge era, a new vision for KM is required. We need to rethink how we design new models for KM that meet the following challenges:

- Leveraging knowledge involves a combination of both explicit and tacit knowledge. The major challenge is to properly address the tacit dimension of knowledge. At the heart of KM lie people. Consequently, traditional technology-push models of KM have to be replaced with new models that reflect the human side of knowledge. This requires a radical shift in emphasis from a focus on know-what to a focus on know-how and know-who. In the future, people-driven implementations of KM that harness tacit knowledge need to be the norm rather than the exception.
- Knowledge is inherently complex and a knowledge environment is a complex adaptive system comprising many interacting identities in which cause and effect relationships are intertwined and cannot be distinguished (Holland, 1995; Snowden, 2002). A knowledge environment, thus, has a non-deterministic character and can evolve in inherently non-linear and unpredictable ways. Hence, the challenge is to propose KM models that can approach knowledge from a complexity perspective. In these models, knowledge should be regarded as a living entity rather than managed as a static object or a predetermined process. Recognizing that knowledge is complex in nature and that emergence and self-organization are the effective ways to cope with complex systems (Holland, 1998), the solution is to evade the control mechanisms of the institutions and let knowledge environments develop and emerge naturally, in a freeform way. KM models need thus to follow an emergent bottom-up approach, driven by the knowledge worker. This would mean a shift from command-and-control to coordinate-and-channel and from hierarchy to wirearchy, defined by Husband (1999) as ''a dynamic two-way flow of power and authority based on information, knowledge, trust and credibility enabled by interconnected people and technology''.

5. Personal knowledge management

Knowledge is inherently personal. In his theory of tacit knowledge, Polanyi (1966) focuses on the tacit and personal dimension of knowledge. Polanyi's central thesis is that all knowledge is personal because all knowledge is either tacit or rooted in tacit knowledge. Echoing Polanyi in his view of tacit knowledge, Nonaka and Konno (1998) write: ''Tacit knowledge is highly personal [. . .] [It] is deeply rooted in an individual's actions and experience as well as in the ideals, values, or emotions he or she embraces'' (p. 42). Likewise, Drucker (1993) suggests that knowledge is ''embodied in a person; created, augmented or improved by a person [. . .] applied by a person [. . .] used or misused by a person'' (p. 210; cited in Wright,

2005, p. 156). And, Wilson (2002) points out that in contrast to data and information, knowledge can never be managed, except by the individual knower.

In the last couple of years, recognizing that knowledge is personal in nature, there has been a growing interest in Personal Knowledge Management (PKM) as a new model to KM. PKM represents a bottom-up approach to traditional KM directed at the needs of individual knowledge workers (Pollard, 2008). It ''focuses on helping individuals become more effective in personal, organizational and social environments'' (Gorman and Pauleen, 2011, p. 1).

There are only few PKM models discussed in the literature. Dorsey (2000), cited in Wright, 2005), for instance, proposes a PKM model encompassing seven components:

1. Retrieving information.
2. Evaluating information.
3. Organizing information.
4. Analyzing information.
5. Presenting information.
6. Securing information.
7. Collaborating around information.

Smedley (2009) suggests a PKM model based on Nonaka and Takeuchi's SECI model, relating traditional organizational KM to individual knowledge acquisition and management processes. In general, most of the PKM models discussed in the literature emphasize PKM processes in knowledge work, such as problem solving (Wright, 2005), sense-making (Snowden *et al.*, 2011), finding and interpreting information, negotiating meaning, engaging in conversations with others and developing ideas (Efimova, 2005), information acquisition, information processing and social activities (Pollard, 2004), gather, classify, store, search, retrieve, and share knowledge (Grundspenkis, 2007), aggregate, understand, and connect (Jarche, 2010), anticipate, explore, find, connect, learn, and act (Gorman and Pauleen, 2011), scan and reinvent, vet and filter, invest in your networks, and get out of your office (Prusak and Cranefield, 2011).

Generally, similar to traditional KM models, the PKM models proposed in the literature remain focused on knowledge as a process. As pointed out in section 3.2, organizing KM into a set of predefined processes is a clear view of KM as a simple or complicated linear process rather than a complex process. The linearity of the PKM process is not well adjusted to describing what is actually going on in KM in a world of increasing complexity and radical discontinuous change. A KM process that works for one knowledge worker may not work for another. In each new context, KM is a unique complex process and is the result of self-organized and emergent processes that do not follow any particular order.

In light of the shortcomings of traditional KM and PKM approaches outlined previously, we discuss in the next section an alternative KM/PKM model that has the potential to align with the shifts and critical challenges of the new knowledge environments characterized by increasing complexity and fast-paced change. This new perspective aggregates the personal and network aspects of knowledge and views knowledge as a personal network rather than as a thing or process.

6. Knowledge as a personal network

In this section, we introduce and discuss in detail the *PKN model* which represents an alternative perspective on KM and PKM. The PKN model meets the challenges outlined in section 4. It addresses the explicit as well as the tacit dimension of knowledge and approaches knowledge from a complexity perspective. The PKN model is driven by the concepts of:

- personal knowledge networks (PKN); and
- knowledge ecologies.

6.1 Personal knowledge networks

The PKN model recognizes the personal and network dimensions of knowledge. It starts from the knowledge worker and views KM as the continuous creation of a personal knowledge network (PKN). A PKN shapes the knowledge home and the identity of the individual knowledge worker. For each knowledge worker, a PKN is a unique adaptive repertoire of:

- Tacit and explicit knowledge nodes (i.e. people and information) (external level).
- One's theories-in-use. This includes norms for individual performance, strategies for achieving values, and assumptions that bind strategies and values together (conceptual/internal level).

In the PKN model, the result of KM is a restructuring of one's PKN, that is, an extension of one's external network with new tacit and explicit knowledge nodes (external level) and a reframing of one's theories-in-use (conceptual/internal level).

The concept of theories-in-use was introduced by Argyris and Schön (1978) within an organizational learning context. An organization/individual theory-in-use includes norms for corporate/individual performance, strategies for achieving values, and assumptions that bind strategies and values together. Argyris and Schön (1978, 1996) draw on the notion of theory-in-use to present their view of organizational learning. According to the authors, organizational learning is the process of detecting and correcting errors. It takes account of the interplay between the actions and interactions of individuals and higher-level organizational entities such as departments, divisions, or groups of managers. Each member of an organization constructs his own representation of the theory-in-use of the whole. Organizational learning then occurs when individuals within an organization experience a problem (error detection) and work on solving this problem (error correction). Error correction happens through a continuous process of organizational inquiry, where everyone in the organizational environment can inquire, test, compare and adjust his theory-in-use, which is a private image of the organizational theory-in-use. Effective organizational inquiry then leads to a reframing of one's theory-in-use, thereby changing the organizational theory-in-use.

Argyris and Schön (1996) use the concept of theory-in-use as starting point for what they termed double-loop learning. The authors define double-loop learning as ''learning that results in a change in the values of theory-in-use, as well as in its strategies and assumptions'' (p. 21). They contrast double-loop learning with single-loop learning defined as ''learning that changes strategies of actions or assumptions underlying strategies in ways that leave the values of a theory of action unchanged'' (p. 20).

Double-loop learning starts from a learner's mental model (i.e. theory-in-use) defined by base norms, values, strategies, and assumptions, and suggests critical reflection in order to challenge, invalidate, or confirm the used theory-in-use. Double-loop learning also encourages genuine inquiry into and testing of one's actions and requires self-criticism, i.e. the capacity for questioning one's theory-in-use and openness to change the same as a function of learning. The result of reflection, inquiry, testing, and self-criticism would then be a reframing of one's norms and values, and a restructuring of one's strategies and assumptions, according to the new settings.

Argyris and Schön (1996) further stress that double-loop learning is essential for productive organizational learning within rapidly changing and uncertain settings. As they put it ''long-term effectiveness depends on the possibility of double-loop learning'' (p. 96) and ''values that govern double-loop organizational inquiry are foundational to sustained productive organizational learning'' (p. 246).

6.2 Knowledge ecologies

At the heart of the PKN model lie knowledge ecologies. Several KM researchers have used the term knowledge ecology. Por (2000), for instance, defines knowledge ecology as ''a field of theory and practice that focuses on discovering better social, organizational, behavioral,

and technical conditions for knowledge creation and utilization'' (p. 3). According to Malhotra (2002), knowledge ecology ''treats knowledge creation as a dynamic evolutionary process in which knowledge gets created and recreated in various contexts and at various points of time'' (Knowledge Ecology for the Era of Discontinuous Change section, para 3). In this article, we present a more knowledge worker-oriented view of knowledge ecology, based on the concept of PKNs, loosely joined. Rather than having to blend into a group or a community, each knowledge worker has her own individual PKN inside a mesh of a knowledge ecology. PKNs are thus the building blocks for knowledge ecologies. A knowledge ecology is defined in this article as a complex, knowledge intensive landscape that emerges from the bottom-up connection of PKNs.

In the following sections, first, we explore the characteristics of a knowledge ecology. Then, we compare knowledge ecologies to other important social aggregates that have been introduced in the CSCL and CSCW literature. These include communities of practice (Lave and Wenger, 1991; Wenger, 1998), knots (Engeström *et al.*, 1999), and intensional networks (Nardi *et al.*, 2002).

6.2.1 Characteristics of knowledge ecology. Some of the key characteristics underlying the notion of knowledge ecology may be deduced from the characteristics of:

- Knowledge.
- Ecology.

Knowledge is inherently personal, social, distributed, and complex (Chatti *et al.*, 2007). And, an ecology is an open, complex adaptive system comprising elements that are dynamic and interdependent (Brown, 1999). Hence, key characteristics of knowledge ecology include: complexity, adaptation, emergence, self-organization, openness, and decentralization.

- *Complexity and adaptation*: A knowledge ecology is a good example of a complex adaptive system. A knowledge ecology is complex in that it is diverse and made up of multiple interconnected elements and adaptive in that it has the capacity to change and learn from experience (Holland, 1995; Holland, 1998). A knowledge ecology, thus, has a non-deterministic character; it can evolve in ways that we may not expect or predict. And, knowledge development in a knowledge ecology is continuous and fluid, with no clearly defined beginning or end.
- *Emergence and self-organization*: As an example of a complex adaptive system, a knowledge ecology holds emergent properties and includes self-organized entities. A knowledge ecology is co-constructed and maintained by individuals. It emerges naturally and is derived from the bottom-up connection of multiple PKNs. A knowledge ecology houses the learning that occurs in a bottom-up and emergent manner, rather than learning that functions within top-down and hierarchical structures under the control mechanisms of outside forces.
- *Openness and decentralization*: as with complex systems, ecologies are open and their boundaries are difficult to be determined. And, knowledge is decentralized and ubiquitous in nature. Hence, openness and decentralization are central attributes in knowledge ecologies.

6.2.2 Knowledge ecology vs CoP. As a special type of community, Lave and Wenger (1991) introduce the concept of communities of practice (CoP). Wenger *et al.* (2002) define CoP as ''groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis'' (p. 4). Wenger (1998) discusses three dimensions of a CoP (p. 73):

1. How it functions (community): A mutual engagement that bind members together into a social entity.
2. What it is about (domain): A joint enterprise as understood and continually renegotiated by its members.

3. What capability it has produced (practice): The shared repertoire of communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.) that members have developed over time.

A knowledge ecology differs from a CoP on all these dimensions.

According to Wenger, ''the first characteristic of practice as the source of coherence of a community is the mutual engagement of participants'' (p. 73). It is mutual engagement that binds members of a CoP together as a social entity and enables them to define themselves as members of the CoP. Unlike a CoP, a knowledge ecology is a social entity which has no clear boundaries and membership criteria. It involves an emergent network of people not so tightly bound as a CoP. A knowledge ecology is driven by independence and autonomy rather than membership, mutual engagement, and belonging to a community. Rather than being forced to interact intensely with other members of a CoP, within a knowledge ecology, everyone can rely on her PKN. Often, people turn to their personal relations in order to learn and get their work done, rather than trying to get access to a well-established community of mutual engagement. Wenger further stresses that the kind of coherence that transforms mutual engagement into a CoP requires work and asserts that ''the work of ''community maintenance'' is thus an intrinsic part of any practice'' (p. 74). In a knowledge ecology, however, people focus on forming and maintaining their PKNs and sustaining dense relations with nodes in their PKNs rather than maintaining the CoP to which they belong.

Wenger states that ''the second characteristic of practice as a source of community coherence is the negotiation of a joint enterprise'' (p. 77). According to Wenger, a CoP involves organizing around some particular area of knowledge (i.e. a shared domain of interest) that gives members a sense of joint enterprise and shared identity. Membership in a CoP implies a commitment to the domain and a continuous negotiation of a joint enterprise. A CoP is thus a homogeneous social entity consisting of members with a joint enterprise and a shared domain of interest. Unlike CoPs, knowledge ecologies are not bound by a shared practice, a joint enterprise, or an overarching domain. They are open, flexible, heterogeneous, and multidisciplinary social entities. In a knowledge ecology, people continuously create their PKNs which shape their identity and knowledge home, rather than create a shared identity through engaging in and contributing to the practices of a CoP. Wenger further notes that ''communities of practice are not self-contained entities. They develop in larger contexts – historical, social, cultural, and institutional – with specific resources and constraints'' (p. 79). Consequently, the practice of a community is profoundly shaped by conditions outside the control of its members due to external efforts to maintain influence and control over the practice. In contrast to CoPs, knowledge ecologies are not positioned within a broader system and are not bound to the control of any external force. They emerge naturally without strong predetermined rules or external authority. Knowledge ecologies are thus self-controlled and self-contained entities.

Wenger notes that ''the third characteristic of practice as a source of community coherence is the development of a shared repertoire [. . .] The repertoire of a community of practice 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 repertoire combines both reificative and participative aspects'' (pp. 82-3). In contrast to CoPs, knowledge ecologies lack a shared repertoire and are thus open and distributed knowledge domains. The knowledge resources are distributed over different PKNs within a knowledge ecology. Unlike participation in a CoP, where the result is the development of a community's set of shared resources and practices, the result of participation in a knowledge ecology is a restructuring of one's PKN, that is, a reframing of one's theories-in-use (conceptual/internal level) and an extension of one's external network with new tacit and explicit knowledge nodes, i.e. people and information (external level).

6.2.3 Knowledge ecology vs knot. Within an activity theory framework, Engeström *et al.* (1999) note that a great deal of work in today's workplace is not taking place in teams with predetermined rules or central authority but in work communities in which combinations of

people, tasks and tools are unique and of relatively short duration. The authors introduce the concept of knotworking to describe temporal situation-driven combinations of people, tasks, and tools, emerging within or between activity systems. According to the authors, the notion of knot refers to ''rapidly pulsating, distributed, and partially improvised orchestration of collaborative performance between otherwise loosely connected actors and activity systems'' (p. 346). Knotworking is characterized by a ''movement of tying, untying, and retying together otherwise separate threads of activity'' (p. 347). In knotworking, the center does not hold, meaning that the tying and dissolution of a knot of collaborative work is not reducible to any specific individual or fixed organizational entity as the center of control or authority. The authors contrast knots to communities of practice, noting the differences between the two in terms of knots' loose connections, short duration of relationships, and lack of shared lore (Engeström *et al.*, 1999) (cited in Nardi *et al.*, 2002, p. 230).

Knowledge ecologies are similar to knots in that they enable the formation of networks between loosely connected individual actors. These networks have no center and rely on distributed control and coordinated action between individual actors. Knowledge ecologies and knots, however, differ in several important points. Knots are constituted by temporary relationships among Knots' actors who aggregate to accomplish a specific task and disaggregate immediately afterwards. And, knots' configurations are in a sense predictable due to the well-defined practices of the actors and their predetermined individual roles. Knowledge ecologies, by contrast, are formed by long-term personal relationships among individuals who self-organize in highly flexible, dynamic, and unpredictable networks, without predetermined roles.

6.2.4 Knowledge ecology vs intensional network. Nardi *et al.* (2002) note that ''the most fundamental unit of analysis for computer supported cooperative work is not at the group level for many tasks and settings, but at the individual level as personal social networks come to be more and more important'' (p. 205). The authors develop the concept of intensional networks to describe ''the personal social networks workers draw from and collaborate with to get work done'' (p. 207). The authors further use the term NetWORK to refer to the ''ongoing process of keeping a personal network in good repair'' (p. 216). Key NetWORK tasks include (p. 216):

- building a network, i.e. adding new contacts to the network so that there are available resources when it is time to conduct joint work;
- maintaining the network, where a central task is keeping in touch with extant contacts; and
- activating selected contacts at the time the work is to be done.

Nardi *et al.* compare intensional networks to communities of practice and knots. The authors note that intensional networks differ considerably from communities of practice stating that intensional networks are personal, more heterogeneous, and more distributed than communities of practices. According to the authors, intensional networks also differ from knots in several ways. First, intensional networks often involve long-term relationships. Second, the joint work may last for long or short periods of time. Third, the knotworking that occurs within established institutions is more structured in terms of the roles it draws on. In contrast, work that is mediated by intensional networks results in more flexible and less predictable configurations of workers. Fourth, in intensional networks, workers are not thrown together in situation dependent ways or assembled through outside forces. Instead, work activities are accomplished through the deliberate activation of workers' personal networks that have been carefully cultivated, often over many years.

Intensional networks are at the core of the knowledge ecology concept. One of the crucial skills of a knowledge networker within a knowledge ecology is her ability to NetWORK; that is build, maintain and activate her personal network to get her work done or learning goal achieved. Nardi *et al.*'s intensional networks, however, only focus on the external personal social network of the learner and do not consider her conceptual and internal knowledge networks; that is the norms, values, strategies, and assumptions, which form the learner's theories-in- use. Unlike intensional networks, PKNs, which are at the heart of the knowledge

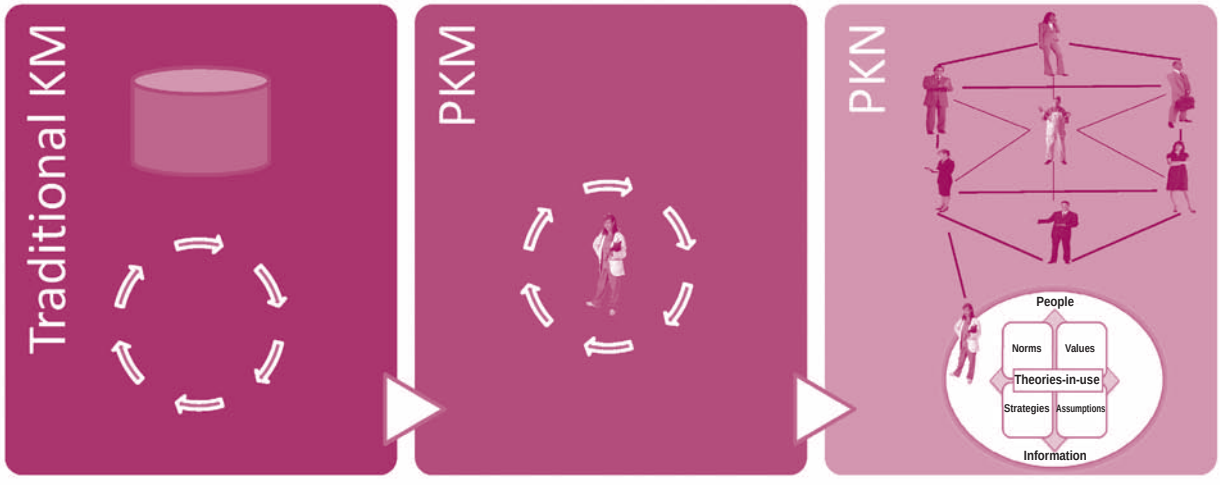
ecology concept, address the personal networks of a learner at both external and conceptual/internal levels.

Moreover, a knowledge ecology is a more general concept than intensional networks. Intensional networks are the elementary building blocks of knowledge ecologies which, by definition, are derived from the overlapping of different intensional networks. Nardi *et al.* admit that joint activity is accomplished by the assembling of sets of individuals derived from overlapping constellations of personal networks. The authors, however, place a heavy emphasis on the NetWORKing process, discuss the characteristics of intensional networks as ego-centric networks that arise from individuals and their communication and workplace activity, but do not address the characteristics of the knowledge domains that emerge out of the interacting intensional networks. In this article, we referred to these knowledge domains as knowledge ecologies and we characterized them as emergent, highly dynamic, complex, and self-organized social entities.

7. From PKM to PKN

In the previous section, we discussed the PKN model as an alternative perspective on PKM, based on the concepts of personal knowledge network (PKN) and knowledge ecology. As illustrated in Figure 1, unlike traditional KM/PKM models which view knowledge as a thing or process, the PKN model views knowledge as a personal network. The PKN model shares with the PKM model a core proposition, that knowledge is fundamentally personal in nature. However, the view of KM as a continuous creation of a PKN, at both conceptual/internal and external levels, encompassing theories-in-use, tacit knowledge nodes (i.e. people) and explicit knowledge nodes (i.e. information) is quite distinctive. Moreover, the PKN model puts a heavier emphasis on the network dimension of KM. In the PKN model, KM starts from the knowledge worker and occurs within knowledge ecologies, which are self-organized and emergent networks of PKNs. Knowledge ecologies house self-directed KM that occurs in an open and bottom-up manner, rather than KM that functions within a structured context shaped by command and control, such as working groups and CoPs. Furthermore, in contrast to the proposed PKM models, the PKN model, which is driven by organizational learning theories (i.e. double-loop learning), stresses the learning dimension in KM and provides a framework for the convergence of KM and organizational learning around a knowledge worker-centric work and learning environment. The PKN model suggests that learning is about work, work is about learning, and both view knowledge as a personal network.

Figure 1 From PKM to PKN



The PKN model further stresses the convergence of personal and organizational KM. In the PKN model, PKM and OKM are tightly intertwined. In practice, the PKN model to KM implies new roles for the organization. The application of the PKN model in a corporate context suggests that the organization needs to put the knowledge worker at the center and support a wide variety of self-directed knowledge work and learning experiences within and beyond the organizational boundaries and across different contexts. It further needs to act as an agile knowledge-networking organization that helps knowledge workers continuously build their PKNs in an effective and efficient way, by providing a freeform and emergent environment conducive to networking, inquiry, and trial-and-error; that is an open environment in which knowledge workers can make connections, see patterns, reflect, (self)-criticize, detect/correct errors, inquire, test, challenge and eventually change their theories-in-use, thus changing the organizational theories-in-use. We referred to these open, emergent, and self-organized work and learning environments as knowledge ecologies.

8. Conclusion

In this article, we reviewed previous models of KM and PKM and explored their failure to cope with the fast-paced change and critical challenges of the new knowledge era. A major reason of this failure is that KM is more than static content and predetermined process, and technology is only a secondary issue. We further highlighted the crucial need for new KM models that have the potential to overcome the deficiencies of previous models. We then discussed the PKN model as an alternative model to KM and PKM that has the potential to align with the shifts and critical challenges of the new knowledge environments characterized by increasing complexity and fast-paced change. The PKN model views knowledge as a personal network and represents a knowledge ecological approach to KM. The PKN model suggests KM as a continuous creation of a personal knowledge network (PKN), at both conceptual/internal and external levels, encompassing theories-in-use, tacit knowledge nodes (i.e. people) and explicit knowledge nodes (i.e. information). At the heart of the PKN model lie knowledge ecologies, where personal and organizational KM can converge. In essence, a knowledge ecology is a complex adaptive system that emerges from the bottom-up connection of PKNs. As with complex adaptive systems, a knowledge ecology holds emergent properties, includes self-organized entities, and can evolve in ways that we may not expect or predict. Knowledge ecologies blur the boundaries of work and learning and harness the power of PKNs.

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