LaaN: Convergence of Knowledge Management and Technology-Enhanced Learning

Mohamed Amine Chatti, Ulrik Schroeder, and Matthias Jarke

Abstract—Knowledge Management (KM) and Technology-Enhanced Learning (TEL) have attracted attention over the past two decades and are meanwhile considered as important means to increase individual and organizational performance. There is, however, a wide agreement that traditional KM and TEL models have failed to cope with the fast-paced change and critical challenges of the new knowledge era. In this paper, we propose a vision for future KM/TEL approaches which aims to fulfill the needs of the new knowledge landscape by introducing the Learning as a Network (LaaN) theory as a new learning theory characterized by the convergence of KM and TEL within a learner-centric knowledge environment. We further discuss a possible implementation of the LaaN theory based on the personal learning environment (PLE) concept.

Index Terms—Technology-enhanced learning, knowledge management, lifelong learning, personalization, LaaN, knowledge ecology.

1 Introduction

The new knowledge era is defined by rapid knowledge development. "It is the nature of knowledge," Drucker [1] stresses, "that it changes fast and that today's certainties always become tomorrow's absurdities" (p. 95). In the knowledge society, Drucker argues, "knowledge is the primary resource for individuals and for the economy overall" (p. 95). Drucker [2] further stresses that "knowledge worker productivity is the biggest of the 21st century management challenges" (p. 157). Since its introduction in the early 1990s, Knowledge Management (KM) has approached the challenge of increasing knowledge worker productivity. There is, however, a wide agreement that most KM efforts have failed to address this challenge [3], [4], [5], [6]. Similarly, over the last decade, it has been widely argued that Technology Enhanced Learning (TEL) could transform the way we learn. However, despite isolated achievements, TEL has not really succeeded yet in revolutionizing our education, improving learner performance, and reflecting the rapid change of knowledge. Brown and Adler [7], for instance, write:

> In the 20th century, the dominant approach to education focused on helping students to build stocks of knowledge and cognitive skills that could be deployed later in appropriate situations. This approach to education worked well in a relatively stable, slowly changing world in which careers typically lasted a lifetime. But the 21st century is quite different. The world is evolving at an increasing pace. (p. 30)

- *M.A. Chatti and U. Schroeder are with Lehr- und Forschungsgebiet Informatik 9, RWTH Aachen University, Ahornstr. 55, Aachen D-52056, Germany. E-mail: {chatti, schroeder}@informatik.rwth-aachen.de.*
- *M. Jarke is with Lehrstuhl Informatik 5, RWTH Aachen University, Ahornstr. 55, Aachen D-52056, Germany. E-mail: jarke@informatik.rwth-aachen.de.*

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Obviously, current models of KM and TEL have failed to address the problem of knowledge worker and learner performance and cope with the fast-paced change of the new knowledge society. Hence, there is a crucial need for new KM and TEL models to meet the challenges of rapidly changing knowledge and increasingly complex knowledge environments. This introduces a considerable number of challenges.

In many cases, KM and TEL were studied in isolation. Thus, different and often incompatible concepts and tools were developed. Meanwhile, there exists a growing network of researchers which argues for an adjustment by emphasizing the close relationships between KM and TEL [8], [9], [10], [11], [12], [13], [14]. In practice, however, the two fields are still evolving down separate paths. The recognition of the strong links between KM and TEL implies that there is a growing recognition for the need to develop new models where the differences between KM and TEL converge toward a lifelong learning experience.

Moreover, it is crucial to address what today's knowledge workers/learners need. This implies a need for new KM/TEL models that start from the knowledge workers/learners and satisfy their unique needs in order to achieve a personalized learning experience for everyone.

In this paper, we take the challenge of investigating the flaws of traditional KM and TEL models; thereafter we develop a new vision of learning defined by the convergence of KM and TEL concepts into one solution toward a new model of personalized and ecological learning through the continuous creation of a personal knowledge network.

2 Knowledge Management

Knowledge Management 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.

2.2 Knowledge as a Process

The more recent KM literature stresses the importance of the people side of KM and acknowledge the input of individuals in making KM effective [5], [15], [16], [17], [18], [19], [20]. 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, share the view according to which knowledge is regarded as a process. Almost all this literature includes references to a common set of processes with respect to knowledge. These include: acquisition, creation, development, dissemination, sharing, and use. Furthermore, this literature often concentrates on the notion of the duality of knowledge (e.g., tacit versus explicit [19], participation versus reification [21]) and moves the focus to the distinction and conversion between tacit and explicit knowledge.

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 [19] 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 process involves four different modes of knowledge creation, namely *S*ocialization, *E*xternalization, *C*ombination, and *I*nternalization. This knowledge creation model has been referred to as the SECI model [22].

3 Deficiencies in Current KM Approaches

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. In practice, however, KM has not demonstrated any competitive advantage to the organizations that have invested in it and most of the KM initiatives have failed [3], [5], [6], [20], [23], [24]. Such failures basically result from the practice to see KM mainly as a technology issue [3], [4], [25] 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 [26] 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 [20], [25], [27], [28]. 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 [29]. This undocumented, hard-to-articulate knowledge is what has been called tacit knowledge [30]. For Polanyi, "we can know more than we can tell" (p. 4). Likewise, Drucker [31] disputes the notion that tacit knowledge can be managed. Nonaka and Takeuchi [19] 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 [21] 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 he/she is willing to take the time to capture his/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 [32]. 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 [33]. Snowden [34] 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 [22] 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 Management 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 [24], 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 learned that could be reapplied by others again and again was unrealistic" (para 6). In the same direction, Siemens [35] 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 [19], [36], [37].

Nonaka and Takeuchi [19], 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 and learning, 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. [23] 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 Technology Enhanced Learning

Over the past decade the Learning Management System (LMS) has become an essential element of Technology Enhanced Learning. The emergence over the past couple of years of Web 2.0 technologies has provided new opportunities for alternative TEL solutions, often referred to as TEL 2.0 or E-Learning 2.0.

4.1 Learning Management Systems

Most TEL solutions today are provided via so called Virtual Learning Environments (VLE). Examples include Learning management Systems, Learning Content Management Systems (LCMS), Course Management Systems (CMS), or Content Management Systems (CMS) such as Blackboard, Desire2Learn, Moodle, Sakai, CLIX, L2P, ATutor, ILIAS, Plone, or Drupal [38]. In the remainder of this paper, the term LMS will be used to refer to the different VLE implementations outlined above. The LMS has dominated the TEL landscape in higher education for the past decade and has become a core part of the academic experience for most education institutions [39].

4.2 TEL 2.0

The rise over the past couple of years of Web 2.0 technologies with more support for collaboration and networking (e.g., blogs, wikis, RSS, social bookmarking, social tagging, podcasting) has provided new opportunities for alternative TEL solutions than LMS. The emergence of Web 2.0 technologies has also led to the rise of terms like "digital natives," "net generation," or "new millennium learners (NML)," which relate to the new ways in which learners interact with modern information and communication technologies [40], [41]. As a result of this movement, TEL researchers and educational institutions have been focusing on how to incorporate the new Web trends into the learning process and how to harness and apply Web 2.0 technologies to create new learning experiences and learn across groups, communities, and networks. TEL via Web 2.0 technologies has been referred to as TEL 2.0 or E-Learning 2.0 [7], [42].

The emergence of Web 2.0 technologies has also triggered intensive discussions on the extent to which tools should be separated from or integrated within LMSs [43]. In an attempt to make the LMS more flexible and useful, LMS providers are rapidly incorporating Web 2.0 features into their offerings. Moreover, over the last few years, learning institutions are increasingly embracing open educational resources (OER) and are opening their courses and making them publicly available. Examples of open content initiatives include the MIT OCW project, YouTube Edu, iTunes U, OpenER (OUNL), and OpenLearn (OUUK) [44]. Furthermore, a growing number of teachers are starting to integrate emerging Web 2.0 tools into their courses and adopt the notion of students actively participating in the learning process. Students are increasingly encouraged to explore and use freely available Web 2.0 services like Delicious, Flickr, YouTube, Slideshare, Google Docs, and Twitter, connect with peers and share course content via social networking platforms, cocreate content using wikis, and publish their thoughts in personal or group blogs. Freedman [45] and McLoughlin [46], for instance, provide examples of classroom projects based on Web 2.0 tools.

Recently, there has also been few experimentations in the development of distributed online courses based on Web 2.0 tools, referred to as massive open online courses (MOOC). An example of a MOOC was the Manitoba's Connectivism course developed in the fall of 2008. The main aim of a MOOC is to support network learning in a distributed environment in which students and instructors employ multiple online services and applications [40].

5 Deficiencies in Current TEL Approaches

Over the last two decade, it has been widely argued that TEL could respond to the needs of the new knowledge society and transform the way we learn. However, despite isolated achievements, TEL has not really succeeded yet in revolutionizing our education and learning processes [7]. Similar to KM, such failures basically result from the heavy emphasis on knowledge as a thing and learning as a predetermined process.

5.1 Knowledge as a Thing

Similar to KM, current TEL approaches are following a static and predefined representation of knowledge and are mainly focusing on content delivery. In fact, TEL has always been connected to computer-based delivery of learning objects (LO). As outlined in Section 4.1, most TEL today is designed, authored, organized, and delivered via LMSs as statically packaged online modules, following the pattern of modularization of courses and the isolation of learning into discrete units [47]. In most of the cases, an initially paper-based learning resource is just converted into a digital form and a classroom training event is transformed into an online course where learning objects are assembled and managed via central standards-conformant LMSs. As Downes [42] writes "The learning management system takes learning content and organizes it in a standard way, as a course divided into modules and lessons, supported with quizzes, tests and discussions, and in many systems today, integrated into the college or university's student information system" (Where We Are Now section, paragraph 4).

The view of learning as course delivery and learning resources as learning objects has led to the implementation of large and centralized learning object repositories (LOR) of context-free and reusable content described by metadata. Complex standards have emerged to make learning objects shareable and learning object repositories interoperable. Learning providers often try to deliver SCORM-compliant content. In order to achieve interoperability between learning repositories, different communication frameworks for querying have been proposed, such as the universal interoperability layer Simple Query Interface (SQI) [48].

This view of knowledge as an object that can be stored and reused makes that what is presented as learning management is simply content management under a new label. However, as discussed in Section 3.1, content represents only one side of the knowledge equation, namely the explicit knowledge side. Furthermore, capturing and storing knowledge as reusable learning objects in centralized LORs makes that knowledge can be isolated from its context, which is crucial in learning.

5.2 Learning as a Predetermined Process

LMS-driven TEL approaches share the view according to which learning is regarded as a process limited by the duration of the semester or term. As Mott and Wiley [49] put it: "at the end of each semester, courses are routinely "deleted" and the learners' networks are gone, with no record left behind of the activity and learning that occurred within them. This is a pattern that repeats from semester to semester, throughout a student's learning career at a particular institution" (Artificial Time Constraints in the CMS section, paragraph 4). This view of learning as a semester-bound process conflicts with the nature of learning. Learning is continuous and fluid and cannot be reduced to a process with clearly defined beginning and end.

Moreover, current TEL solutions share a primary focus on the automation of the learning process. A strong emphasis has often been placed on how to control, centralize, and standardize the learning process using technology. The view of learning as an institution-controlled process has led to the development of instructional design specifications that aim to describe a learning flow in a standardized manner, such as IMS Learning Design (IMS-LD) [50]. The automation of the learning process fails to address the complex and uncertain dimensions of knowledge and learning. The learning process cannot be reduced to a string of predetermined processes. It rather emerges through a series of processes that cannot be predicted or anticipated. Organizing the learning process into units with predefined content and learning outcomes is a clear view of learning as a linear process. The linearity of the institution-controlled learning process is not well adjusted to describing what is actually going on in learning in a world of radical discontinuous change. In each new context, learning is a unique process and is the result of emergent processes that do not follow any particular order.

Furthermore, current TEL solutions are designed with the primary focus on control and are driven by the needs of the educational institution. They follow a top-down, one-size-fits-all approach driven by knowledge-push and suffer from an inability to give learners the opportunity to contribute to the learning process in significant ways, and to satisfy the heterogeneous needs of many learners. Current TEL 2.0 solutions also continue to privilege the teacher/institution, rather than the learner, as the central element in the learning experience. These solutions share a common emphasis on how to best integrate the emergent Web 2.0 technologies into the learning process without influencing the traditional pedagogical principles and policies imposed by formal educational institutions. The result is that technology is often applied in the existing institutional context of learning controlled by the institution and organized into courses with preselected tasks, prescribed tools, and predetermined learning outcomes.

6 KM and TEL as Two Sides of the Same Coin

In an organizational context, KM and TEL have attracted attention over the past years and are meanwhile important tasks to increase competitive advantages of an organization. In practice, however, KM and TEL fields have evolved down separate paths. The two fields used incompatible technology infrastructures and were divided by the words they use and by some of their fundamental assumptions about users. In a corporate context, most companies treated knowledge and learning as separate entities. KM and TEL have been kept separate from an organization structure point of view and were managed by different departments. While KM practices are managed by the IT department, TEL programs such as mentoring, on-the-job training, workshops are often run by the human-resources department [3], [8]. In research, the KM community and the TEL community work on different problems, do not really speak the same language, use different tools, rely on different authors and base their work in different concepts [11].

Over the past few years, companies and researchers are starting to recognize relationships and intersections between

KM and TEL fields and to explore the potential and benefits of their integration. For instance, Grace and Butler [10] propose a framework for learning in organizations driven by LMS and highlight the roles that LMS can play to support KM. Lytras et al. [13] present a Semantic Web approach to link TEL and KM, where learning objects are used in a KM system in order to provide learning material. Liaw et al. [51] propose a mobile learning system based on the activity theory as a KM tool. The aim of the system is to help learners search, retrieve, create, share, and manage knowledge. Dunn and Iliff [8] identify community and collaboration, with technology supporting connections and relationships, as a means to bring KM and TEL together. Efimova and Swaak [9] discuss cases of using KM methods, namely communities of practice, to support TEL efforts within companies. Hackett [11] looks at practices that companies employed to manage learning and knowledge and reports that most of the companies implemented initiatives (e.g., goupware, communities of practice, storytelling) to encourage knowledge sharing within workgroups. Hall [12] suggests that learning solutions can be complemented by several KM components, including expertise directories, information management applications and groupware. Rosenberg [14] points out that e-learning is more than e-training and suggests a combination of training (formal) and nontraining (informal) approaches (e.g., collaboration tools, access to knowledge resources) to support learning and performance in the workplace. With the emergence of Web 2.0 in the last few years, researchers have been focusing on how to leverage Web 2.0 concepts and technologies (e.g., blogs, wikis) to enable a combination of TEL and KM within a social context [52], [53], [54].

In general, most initiatives aiming at the integration of KM and TEL continue to perform in closed and controlled environments. Often, a centralized learning system is offered as a KM tool, or vice versa. Knowledge, however, is distributed and learning is ubiquitous and happening in a world without boundaries. Thus, centralization is inefficient as a coordination mechanism in the context of distributed knowledge. Moreover, the literature which addresses the connection between KM and TEL solutions merely focuses on the intersection or complementary relationship between the two domains. Often, one domain is complemented with components from the other domain. In most of the cases, either TEL content (e.g., learning objects, LMS) is made accessible to knowledge management solutions, or key concepts and tools that fall under KM (e.g., communities of practice, CSCW, SECI model, knowledge assets, knowledge bases) are being applied in a TEL context. In this paper, we go a step forward and argue that KM and TEL initiatives have to fuse and that we should speak about union and fusion of the two fields rather than intersection or complementary relationship between them. In this sense LM and KM can be viewed as two sides of the same coin.

There are clear links between KM and TEL that provide strong evidence for this fusion. The two fields are increasingly similar in terms of input, outcome, and the nature of their underlying processes.

In terms of input, KM and TEL deal with knowledge and learning which are basically two sides of the same coin. Learning is the foundation of knowledge [55]. The future of learning is written in the future of knowledge [56]. "Learning is a peer to knowledge. To learn is to come to know. To know is to have learned" [35, p. 16]. Moreover, in the TEL, Computer-supported collaborative learning (CSCL), and Organizational Learning (OL) literatures, learning is often closely related to knowledge. For instance, Sfard [57] discusses the knowledge-acquisition metaphor of learning, representing a view according to which learning is mainly a process of acquiring desired pieces of knowledge. Paavola et al. [58] explore the knowledge-creation metaphor of learning, meaning that learning is seen as analogous to innovative processes of inquiry where something new is created and the initial knowledge is either substantially enriched or significantly transformed during the process. And, Nonaka and Takeuchi [19] present SECI as a knowledge-creation model for organizational learning.

In terms of outcome, KM and TEL goals are increasingly intertwined and targeted at improvement and effectiveness. Over the past two decades, the interest in KM and TEL as disciplines has been driven by the realization that KM and TEL methods and tools can be instrumental in increasing individual and organizational performance.

Furthermore, KM and TEL share a similar nature of their processes as being inherently human and complex. Both KM and TEL are not static and linear processes. They are rather very dynamic human activities, and action-oriented and open-ended processes.

7 Need for New KM/TEL Models

Obviously, current KM and TEL 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 and learning are, 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 and TEL is required. We need to rethink how we design new models for KM and TEL 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 and TEL lie people. Consequently, current technology-push models of KM and TEL have to be replaced with new models that reflect the human side of knowledge and learning. 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 and TEL that harness tacit knowledge need to be the norm rather than the exception.
- Knowledge is inherently complex. Hence, the challenge is to propose KM and TEL models that can approach knowledge and learning 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

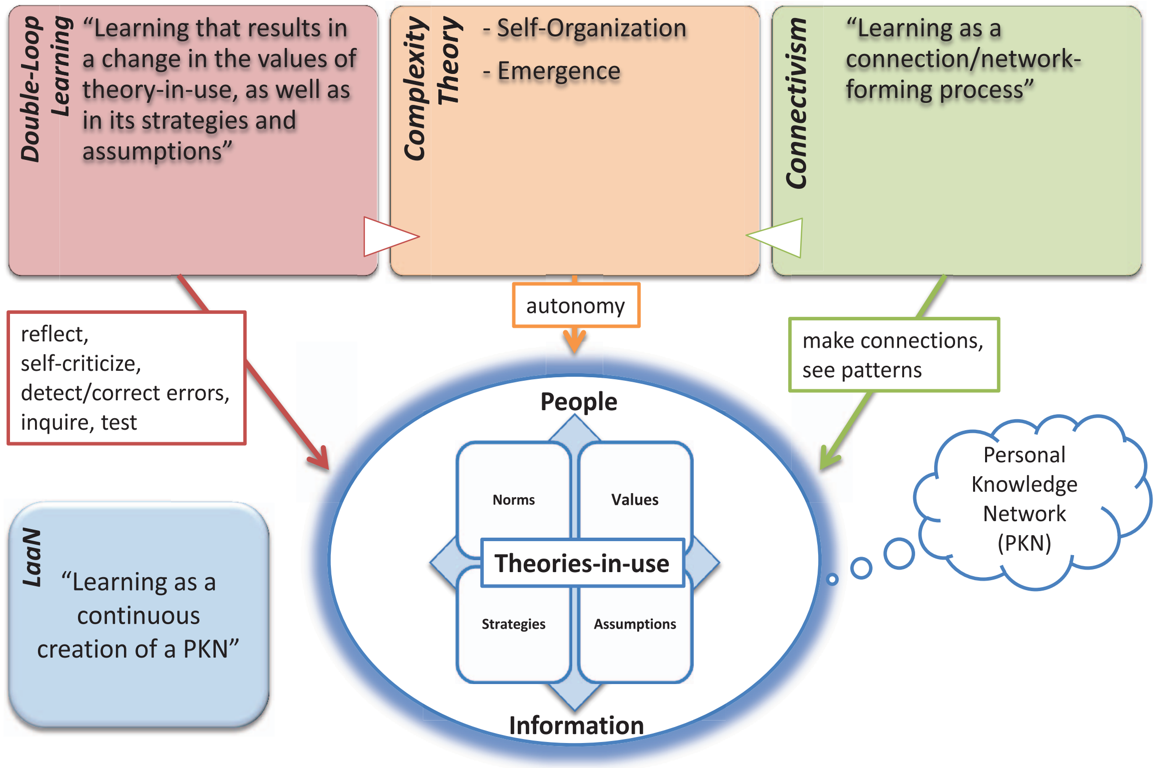

Fig. 1. The LaaN theory.

emergence and self-organization are the effective ways to cope with complex systems, the solution is to evade the control mechanisms of the institutions and let knowledge/learning environments develop and emerge naturally, in a freeform way. KM and TEL models need thus to follow an emergent bottom-up approach, driven by the knowledge worker or learner. This would mean a shift from command-and-control to coordinate-and-channel and from hierarchy to wirearchy, defined by [59] as "a dynamic two-way flow of power and authority based on information, knowledge, trust, and credibility enabled by interconnected people and technology."

- KM and TEL need to be regarded as two sides of the same coin, rather than two ends of a continuum. The challenge is to integrate KM and TEL models to support continuous and lifelong learning for the purpose of increasing individual and organizational performance. An integration model for KM and TEL needs to operate in decentralized and open environment, based on small pieces, loosely joined and distributed control.

In light of these challenges, we discuss in the next sections an alternative KM/TEL perspective characterized by the convergence of KM and TEL within a learner-centric and open knowledge environment. This new perspective views knowledge as a personal network rather than as a thing or process.

8 The LaaN Theory

The Learning as a Network (LaaN) theory draws together some of the concepts behind connectivism [60], complexity theory [34], [61], and double-loop learning [62]. An abstract view of LaaN is depicted in Fig. 1.

Connectivism focuses on making connections (at external, conceptual, and neural levels) and seeing patterns. Connectivism, however, misses some of the douple-loop learning concepts, which are crucial for learning, such as learning from failures, error detection and correction, and inquiry. On the other hand, double-loop learning aims at detecting and correcting errors by changing the values, strategies, and assumptions of the theory-in-use according to the new setting. Double-loop learning, however, does not recognize the power of connections/networks that can help us operate in highly dynamic and uncertain knowledge environments, characterized by increasing complexity and fast-paced change.

Within LaaN, connectivism, complexity theory, and double-loop learning converge around a learner-centric environment. LaaN starts from the learner and views learning as the continuous creation of a **personal knowledge network (PKN)**. A PKN shapes the knowledge home and the identity of the individual learner. For each learner, 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 LaaN, the result of learning is a restructuring of one's PKN, that is, an extension of one's external network with new knowledge nodes (external level) and a reframing of one's theories-in-use (conceptual/internal level) [63].

LaaN-based learning implies that a learner needs to be a good knowledge networker as well as a good double-loop learner. A good knowledge networker is one who has the ability to

- Create, harness, nurture, sustain, and widen her external network to embrace new knowledge nodes.
- Identify connections, recognize patterns, and make sense between different knowledge nodes.
- Locate the knowledge node that can help achieving better results, in a specific learning context.
- Aggregate and remix.
- Cross boundaries, connect, and cooperate.
- Navigate and learn across multiple knowledge networks.
- Help other knowledge networkers build and extend their networks.

Furthermore, a good double-loop learner is one who has the ability to

- Build her own representation of the theories-in-use of the whole.
- Reflect.
- (Self-)criticize.
- Detect and correct errors with norms and values specified by the new setting.
- Inquire.
- Test, challenge, and eventually change her theories-in-use (i.e., her private image of the theories-in-use of the whole) according to the new setting.

In [64], we provided a thorough discussion of the major differences between LaaN and different dominant learning and social theories. These theories are behaviorism, cognitivism, (social) constructivism, situated learning, activity theory, and actor-network theory. Unlike these theories, LaaN promotes a theory of openness and self-organization which puts the learner at the center and represents a knowledge ecological approach to learning. At the heart of LaaN lie **knowledge ecologies**. The knowledge ecology concept will be discussed in detail in the next section.

9 Knowledge Ecology

Several researchers, especially in the area of knowledge management, have used the term knowledge ecology. Por [65], 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 [66], 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, paragraph 3). In this paper, we present a more learner-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 learner has his or 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 paper 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 [21], [67], knots [68], and intensional networks [69].

9.1 Characteristics of Knowledge Ecology

Some of the key characteristics underlying the notion of knowledge ecology may be deduced from the characteristics of

1. Knowledge.
2. Ecology.

Knowledge is inherently personal, social, distributed, and complex [70], [71]. And, an ecology is an open, complex adaptive system comprising elements that are dynamic and interdependent [72]. 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 [61], [73]. A knowledge ecology, thus, has a nondeterministic 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 coconstructed 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.

9.2 Knowledge Ecology versus CoP

As a special type of community, Lave and Wenger [67] introduce the concept of *communities of practice (CoP)*. Wenger et al. [74] defines 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 [21] 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. 82-83). 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 knowledge nodes (external level).

9.3 Knowledge Ecology versus Knot

Within an activity theory framework, Engestrom et al. [68] 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 [68] (see [69, 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 afterward. 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.

9.4 Knowledge Ecology versus Intensional Network

Nardi et al. [69] 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):

1. 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;
2. maintaining the network, where a central task is keeping in touch with extant contacts;
3. activating selected contacts at the time the work is to be done.

Nardi et al. [69] 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 upon. 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/external 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 paper, we referred to these knowledge domains as knowledge ecologies and we characterized them as emergent, highly dynamic, complex, and self-organized social entities.

10 LaaN as a Bridge between KM and TEL

LaaN represents a vision of (professional) learning, where the line between KM and TEL disappears. Unlike traditional KM and TEL perspectives (please refer to Sections 3 and 5), LaaN views knowledge as a personal network rather than as a thing or process. In LaaN, work/learning is viewed from a knowledge worker/learner perspective, and KM and TEL are seen as being primarily concerned with a continuous creation of a Personal Knowledge Network. This ensures that the differences between KM and TEL are converging around a knowledge worker/learner-centric work/learning environment and makes that the roles of KM and TEL are blurring into one, namely supporting the knowledge worker/learner in continuously creating and optimizing their PKNs. In this sense, KM and TEL are not the two ends of a continuum but the two sides of the same coin.

Moreover, LaaN enables the seamless integration of learning and work. The view of learning as the continuous creation of a PKN makes learning and work so intertwined that learning becomes work and work becomes learning. As illustrated in Fig. 2, TEL in LaaN is no longer regarded as an external online training activity separate from the work flow, but rather as a learner-controlled evolving activity embedded directly into work processes.

To note here that, in the last years, there has been a growing interest in Personal Knowledge Management (PKM). PKM represents a bottom-up approach to traditional KM directed at the needs of individual knowledge workers [75]. According to Wright [76], PKM "focuses on how individual workers apply knowledge processes to support their day-to-day work activities—broadly characterized as problem solving—and learning practices" (p. 156). The PKM models discussed in the literature emphasize PKM processes in knowledge work, such as solving problems [76], finding and interpreting information, negotiating meaning, engaging in conversations with others and developing ideas [77], information acquisition, information processing, and social activities [78]. Generally, the proposed PKM models remain focused on knowledge as a process. Unlike these models, LaaN views knowledge as a personal network. LaaN shares with these models a core proposition, that knowledge and learning are fundamentally personal in nature. However, the LaaN view of KM as a continuous creation of a PKN, at both 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, LaaN puts a heavier emphasis on the network dimension of PKM. In LaaN, PKM occurs within knowledge ecologies, which are self-organized and emergent networks of PKNs. Knowledge ecologies house self-directed learning that occurs in an

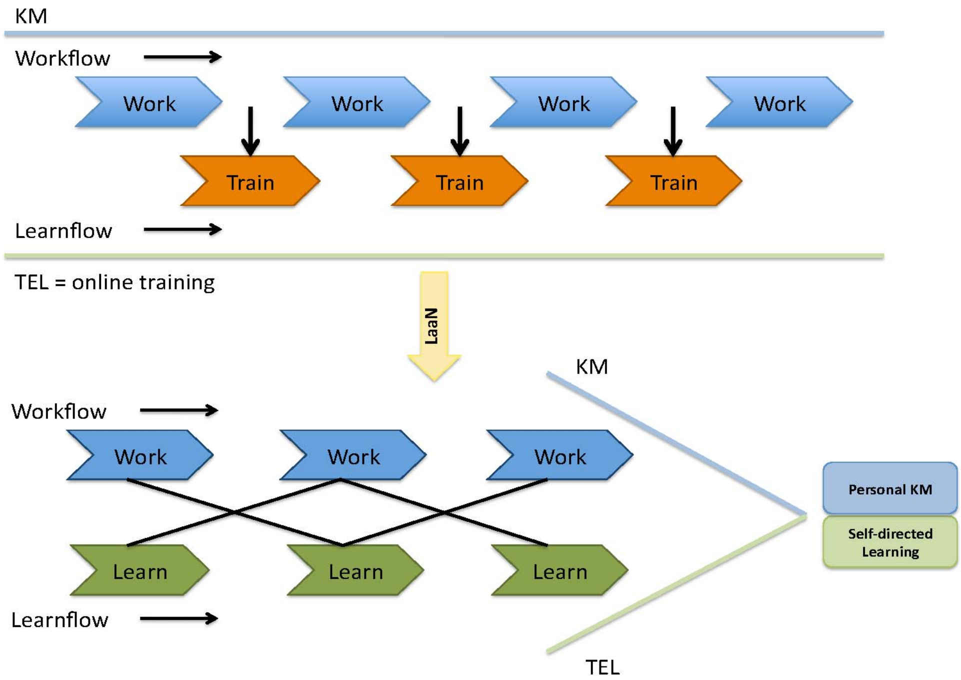

Fig. 2. LaaN: Convergence of KM and TEL.

open and bottom-up manner, rather than learning 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, LaaN stresses the learning dimension in KM and provides a framework for the integration of KM and TEL around a learner-centric knowledge environment.

In the next section, we discuss a possible application of the LaaN theory based on the personal learning environment (PLE) concept, which affirms the role of the knowledge worker/learner in shaping her own working/learning environment that best suits her goals and needs. In the remainder of this paper, we use the terms learner and knowledge worker interchangeably.

11 LaaN and PLE

In today's complex learning environments, characterized by change, movement and dynamism, the challenge is to adopt LaaN-based learning models that engage the (professional) learners and give them more control over their learning experience. LaaN suggests an inversion of control on the learning experience and a shift from knowledge-push to knowledge-pull. The (Professional) Personal Learning Environment concept translates the LaaN principles into actual practice. From a pedagogical point of view, a PLE-driven approach to learning supports a wide variety of learning experiences within and beyond the institutional boundaries. It puts the learner at the center and gives her control over the learning experience. From a technical point of view, as depicted in Fig. 3, a PLE can be viewed as a self-defined collection of services, tools, and devices that help learners build their PKNs. A PLE suggests the freeform use of a set of lightweight and loosely coupled tools and services that belong to and are controlled by individual learners. Rather than being restricted to a limited set of services within a centralized institution-controlled system, the idea is to provide the learner with a plethora of different services and hand over control to her to select, use, and remix the services the way she deems fit. A PLE does not only provide personal spaces, which belong to and are controlled by the learner, but also requires a social context by offering means to connect with other personal spaces in order to harness knowledge within open and emergent knowledge ecologies.

There have been some attempts to define approaches to developing PLEs. PLEs can exist in an ad-hoc manner, for instance through blogs. Van Harmelen [79] suggests "a PLE may be composed of one or more subsystems: As such it may be a desktop application, or composed of one or more web-based services." Attwell [80] asserts that "A PLE is

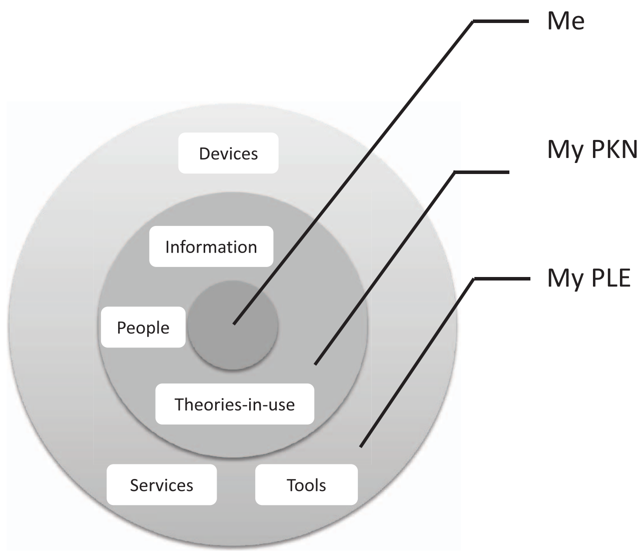

Fig. 3. LaaN and PLE.

comprised of all the different tools we use in our everyday life for learning" (p. 4). Lubensky [81] discusses different ways of PLE development. According to the author, PLEs can be realized as WebTops, desktop applications, content management systems, or in terms of mashups. We discussed in [82] a framework for mashup personal learning environments. The main aim of this framework is to leverage the possibility to plug learning services from multiple sources into a learner-controlled space.

In practice, LaaN-based learning and work implies new roles for the learning institution and the company. In LaaN, the learning institution needs to act as a hub connecting third parties (including other learning institutions, informal/lifelong learning providers, and companies) providing personalized learning experiences to the learners. And, teachers need to step back from their traditional role of instructors and experts. The new role of the teachers is to act as colearners, facilitators, and mentors of the learning experience. The application of LaaN in a corporate context suggests that the company needs to act as an agile knowledge-networking organization rather than a passive training provider. In LaaN, the major task of the learning institution and the company is to help knowledge workers/ learners 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/ learners can make connections, see patterns, reflect, (self)-criticize, detect/correct errors, inquire, test, challenge and eventually change their theories-in-use.

12 Summary

In this paper, we reviewed previous models of KM and TEL and explored their failure to address the problem of knowledge worker and learner performance and cope with the fast-paced change and critical challenges of the new knowledge era. We further addressed how KM and TEL have become essentially two sides of the same coin as the two fields are increasingly similar in terms of input, outcome, and the nature of their underlying processes and highlighted the crucial need for new KM and TEL models that have the potential to overcome the deficiencies of previous models. We discussed the Learning as a Network theory which represents a theoretical framework for future KM and TEL models that have the potential to replace current models. LaaN attempts to bridge the currently existing gap between KM and TEL. It views knowledge as a personal network and represents a knowledge ecological approach to learning. LaaN thus ensures that the differences between KM and TEL are converging around a learner-centric knowledge environment. Finally, we discussed a possible implemenation of the LaaN theory based on the personal learning environment concept.

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Mohamed Amine Chatti received a diploma in computer science from the University of Kaiserslautern, Germany, in 2004 and the PhD degree in computer science from RWTH Aachen University, Germany, in 2010. He is an assistant professor of computer science in the Learning Technologies Group (Informatik 9) at RWTH Aachen University, Germany. His research interests include web information systems, technology-enhanced learning, and knowledge management.

Ulrik Schroeder is a professor of computer science at RWTH Aachen University. He heads the research group Learning Technologies (http://eLearn.rwth-aachen.de). He is also the head of the Center for Innovative Learning Technology (http://www.cil.rwth-aachen.de) and the director of the school laboratory for computer science (InfoSphere) (http://schuelerlabor.informatik.rwth-aachen.de) at RWTH Aachen University. His research interests include assessment and intelligent feedback with a focus on learning processes, Web 2.0 applications and social software in education, mobile Internet and learning, gender mainstreaming in education, and computer science teachers education.

Matthias Jarke is a professor of information systems at RWTH Aachen University and the director of the Fraunhofer FIT Institute of Applied IT in Sankt Augustin, Germany. In his research, he investigates IS support for knowledge-intensive cooperative processes in business, engineering, and culture. As the president of the German Computer Society (GI), he was responsible for the definition of Germany's IT accreditation guidelines. Both his university group and Fraunhofer FIT have been involved in numerous e-learning activities, ranging from the high school level to entrepreneurship training. He serves on a number of national and international advisory boards.