# Layered Knowledge Networking in Professional Learning Environments

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Keywords: Knowledge Management, Technology Enhanced Learning, Lifelong Learning, Professional Learning, Work-Integrated Learning, Personalized Learning, Network Learning.

Abstract: Knowledge Management (KM) and Technology Enhanced Learning (TEL) became a very important issue in modern organizational professional learning and work process integration. Former learning and KM theories which characterize knowledge as a thing or process no longer fit today's digital world where the amount of required information is no more manageable and the half-time of knowledge in general is rapidly decreasing. Younger approaches such as the Learning as a Network (LaaN) theory describe knowledge as complex and emergent and put a heavier focus on knowledge networking. The LaaN theory further stresses the convergence of the learning and work processes in professional learning settings and views KM and TEL as two sides of the same coin. Driven by the LaaN theory, the Professional Reflective Mobile Personal Learning Environments (PRiME) project describes an integrated KM and TEL framework which connects learning and work processes. It enables the professional learner to harness implicit knowledge and offers knowledge networking at three different layers: the Personal Learning Environment (PLE), the Personal Knowledge Network (PKN) and the Network of Practice (NoP). Continuous knowledge networking results in constant evolution of knowledge leading to personal as well as organizational learning.

## 1 INTRODUCTION

Since its introduction in the early 1990s, Knowledge Management (KM) has always played an important role to increase the productivity of knowledge workers and achieve organizational benefits. Mainly following two major approaches regarding knowledge-as-a-thing on the one hand or knowledge-as-a-process on the other hand, KM could not fulfill the high hopes laid in it. Also, the finding that knowledge is something personal in nature could not help out when Personal Knowledge Management (PKM) came up in the past couple of years (Chatti, 2012).

Similarly, over the last decade, Technology-Enhanced Learning (TEL) has been addressed as a possibility to go new ways in education, but as with KM the view of learning as a passive, teacher-driven process where knowledge is viewed as an object that can be transferred from the mind of the teacher to the mind of the students precluded a real innovative success. That did not change with the emergence of the Web 2.0 movement which brought up various tools to connect learners and put them in an active role. The traditional pedagogical principles were, however, kept untouched.

In a professional context, despite the recognition of the strong links between KM and TEL, the two fields are still evolving down separate paths. In this paper, we recapitulate the shortfalls of KM and TEL and present the Learning as a Network (LaaN) theory as a new vision of learning defined by the convergence of KM and TEL concepts into one solution. Furthermore, we present a possible application of the LaaN theory in the frame of the Professional Reflective Personal Mobile Learning Environments (PRiME) Project. PRiME focuses on the convergence of the learning and working processes and proposes an integrated KM and TEL framework that offers layered knowledge networking to foster continuous individual and organizational learning

The remainder of this paper is structured as follows. Section 2 addresses the relationship between professional learning and knowledge management. In Section 3, we briefly discuss the LaaN theory as a theoretical basis for our work. Section 4 presents the conceptual and implementation details of the PRiME project.

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Finally, Section 5 gives a summary of the main results of the paper and outlines perspectives for future work.

## 2 KM AND TEL

In a company context, Knowledge Management (KM) and Technology-Enhanced Learning (TEL) have so far been regarded as two impartial areas. While KM concentrates on knowledge creation and distribution, TEL focuses on formal learning and training of the employees. This tightened perspective can still be read from today's companies' structures. KM and TEL are commonly related to two different departments, namely IT and human resources.

### 2.1 KM

With the emergence of KM in the 1990s, organizations had highest hopes in it to improve the knowledge worker performance and at the same time increase the efficiency of the organization to achieve strategic advantages. In the KM literature, there have been two major views on knowledge, namely knowledge-as-a-thing and knowledge-as-a-process (Chatti, 2012; Chatti et al., 2012).

The idea of knowledge-as-a-thing assumes KM to be most likely simple information management (Hildreth and Kimble, 2002; Kimble et al., 2001; Malhotra, 2005; Wilson, 2002). In general, it covers information capturing, storing, and reusing. Capturing knowledge, however, is not an easy task and moreover very time and effort consuming. The management of knowledge also conflicts with the work process and describes an additional overload. Furthermore, the knowledge-as-a-thing KM models cannot deal with the complex nature of knowledge including e.g. knowledge evolution or its context-sensitivity.

The more recent KM initiatives stress the importance of the people's side of KM and view knowledge as a process. These initiatives often address the duality of knowledge and move the focus to the distinction and conversion between tacit and explicit knowledge. A popular representative of the class of knowledge-as-a-process KM models is Nonaka and Takeuchi's SECI model, which describes knowledge as a spiraling process of socialization, externalization, combination, and internalization which are transforming knowledge between tacit and explicit forms (Nonaka and Takeuchi, 1995). Due to the variable iterations of the four steps, the model creates the impression to be flexible. However, it is as predetermined as all the knowledge-as-a-process KM models trying to describe an automated process for knowledge creation not able to deal with complexity of knowledge and the unpredictable nature of the KM process.

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 (Gorman and Pauleen, 2011; Jarche, 2010; Prusak and Cranefield, 2011; Snowden et al., 2011). PKM recognizes that knowledge as well as learning is personal in nature. It puts the knowledge worker and her tacit knowledge at the center. In contrast to the early KM approaches, the PKM approach shows a bottom-up instead of top-down flow of knowledge. However, the current PKM approaches are still very process-oriented and do not really deal with the relation between personal and organizational KM. So far, there are no underlying, supporting theoretical frameworks for PKM and problems like rapidly changing knowledge with a very short half-life, the complexity of work and its environments, etc. are not considered (Chatti, 2012).

### 2.2 TEL

TEL actually shares the same fate with KM. Summarizing different available approaches, TEL commonly means offering Virtual Learning Environments (VLE). These include Learning Management Systems, Learning Content Management Systems, Content Management Systems, and Course Management Systems. All of them concentrate on the provision of information. Although efforts have been made in regard to interoperability of such information repositories, they are still centralized and commonly under the control of a formal educational institution (Downes, 2005).

In the last years, TEL has been influenced by the emergence of the Web 2.0 movement. The term TEL 2.0 emerged to refer to TEL approaches that adapt new techniques for collaboration, networking, and learners' active participation in the learning process. While that offers great possibilities, TEL did not really change or influence the traditional pedagogical principles behind it. Content is still organized in standard ways, following the top-down approach pushing information to the learners. Gained knowledge is time-limited e.g. semester-bound and not seen as continuous or fluid. By this linear and predefined process, newly gained

knowledge cannot be reused and gets lost (Brown and Adler, 2008; Mott and Wiley, 2009).

### 2.3 Convergence of KM and TEL

Over the past years, companies and researchers are starting to recognize relationships and intersections between the KM and TEL fields and to explore the potential and benefits of their integration (Grace and Butler, 2005; Lytras et al., 2005; Malhotra, 2005). Chatti et al. (2012) go a step further and point out that professional learning and knowledge management can be viewed as two sides of the same coin and stress the need for the seamless integration of the two concepts into one solution for the purpose of increasing individual and organizational performance. The authors introduce the Learning as a Network (LaaN) theory as a bridge between TEL and KM. In the next section, we briefly discuss the LaaN theory as a theoretical basis for our work.

## 3 THE LAAN THEORY

The Learning as a Network (LaaN) theory has been proposed by Chatti (2010a, 2010b) as a new vision of learning towards a new model of personalized and networked learning. LaaN provides the theoretical foundation to address the diverse learning needs of individual learners in today's learning environments characterized by increasing complexity and fast-paced change. LaaN draws together some of the concepts behind connectivism (Siemens, 2005), complexity theory (Holland, 1992, 1998; Snowden, 2002), and double-loop learning (Argyris & Schön, 1978, 1996). An abstract view of LaaN is depicted in Figure 1.

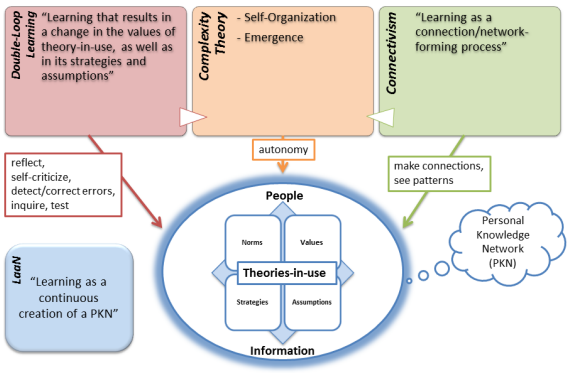


Figure 1: The LaaN Theory (Chatti, 2010a).

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).

LaaN-based learning implies that a learner needs to be a good knowledge networker as well as a good double-loop learner. The ability to create an own representation of knowledge, reflect, (self-) criticize and finally change and correct it is as important as the capability to recognize patterns or find, aggregate, and remix available knowledge nodes.

At the heart of LaaN lie knowledge ecologies. A knowledge ecology is based on the concept of PKNs, loosely joined, and can be defined as a complex, knowledge intensive landscape that emerges from the bottom-up connection of PKNs. Knowledge ecologies house self-directed learning that occurs in a bottom-up and emergent manner, rather than learning that functions within a structured context of an overarching framework, shaped by command and control. As compared to popular social forms that have been introduced in the CSCL and CSCW literature such as communities of practice, knots, coalitions, and intensional networks, knowledge ecologies are more open, more flexible, less predictable, and less controlled (Chatti et al., 2012).

LaaN further represents a vision of professional learning, where the line between KM and TEL disappears. Unlike traditional KM and TEL perspectives, LaaN views knowledge as a personal network rather than as a thing or process. In LaaN, work/learning is viewed from a professional learner perspective, and KM and TEL are seen as being primarily concerned with a continuous creation of a PKN. This ensures that the differences between KM and TEL are converging around a learner-centric work/learning environment and manage that the roles of KM and TEL are blurring into one, namely supporting professional learners 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 Figure 2, professional learning 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 (Chatti et al., 2012).

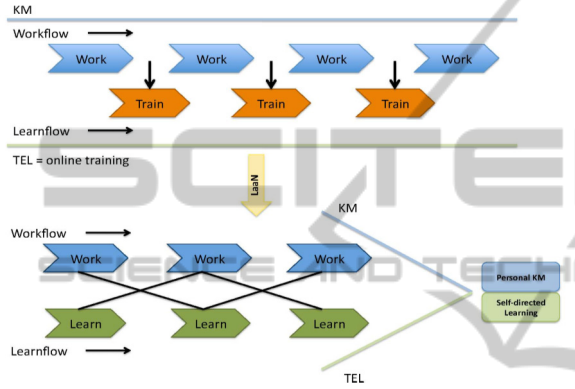


Figure 2: LaaN: Convergence of KM and TEL (Chatti et al., 2012).

In the next section, we present the details of the PRiME project as a possible application of the LaaN theory.

# 4 PRIME

The joint research project Professional Reflective Mobile Personal Learning Environments (PRiME) is conducted by the Learning Technologies Research Group of the RWTH Aachen University and DB Training, Learning & Consulting of the Deutsche Bahn AG. It is funded by the German Federal Ministry of Education and Research with a runtime of three years, finishing in June 2016 (Greven et al., 2014).

PRiME illustrates the LaaN theory in action. It offers an integrated professional learning and knowledge management framework for personal as well as organizational learning, addressing the following objectives:

- Provide an innovative professional learning approach, where informal and network learning converge around a self-directed learning environment.
- Design a work-integrated framework that links mobile job activities and self-directed learning in context.
- Develop and evaluate mobile learning applications to support mobile learning in context.
- Support continuous knowledge networking and reflection at three levels: (a) the personal learning environment (PLE) level where professional learners can annotate learning materials on their mobile tablet devices; (b) these materials can be shared, commented, and rated by peers at the personal knowledge network (PKN) level; (c) the newly generated learning materials can then be shared and used within the company at the network of practice (NoP) level.
- Develop and evaluate learning analytics tools and methods (e.g. dashboards, recommendation, intelligent feedback, context-based search) to support reflective learning at the workplace.

In the next sections, we discuss the underlying concepts and the current implementation results of the PRiME project.

## 4.1 Conceptual Approach

The main goal of PRiME is to offer seamless learning across time, location, and social contexts combining the work and learning processes into one. Context has been identified as a key factor in workplace learning to achieve effective learning activities. Nowadays, professional learners perform in highly complex knowledge environments. They have to deal with a wide range of activities they have to manage every day. Moreover, they have to combine learning activities and their private and professional daily life. The challenge here is thus how to support learning activities across different contexts (Greven et al., 2014, Thüs et al., 2012).

PRiME translates the principles of LaaN into actual practice. In PRiME, a professional learner is a lifelong learner who is continuously creating and optimizing her network. Driven by LaaN principles, PRiME aims at helping professional learners to continuously build their personal networks 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 learners can make connections, see patterns, reflect, (self)-criticize, detect and correct errors, inquire, test, challenge and

eventually change their knowledge; thus changing the organizational knowledge.

The learning process in PRiME is a spiral and cyclic conversion of individual and organizational knowledge at three different layers of knowledge networking and maturity: the personal learning environment (PLE), the personal knowledge network (PKN), and the network of practice (NoP), as depicted in Figure 3.

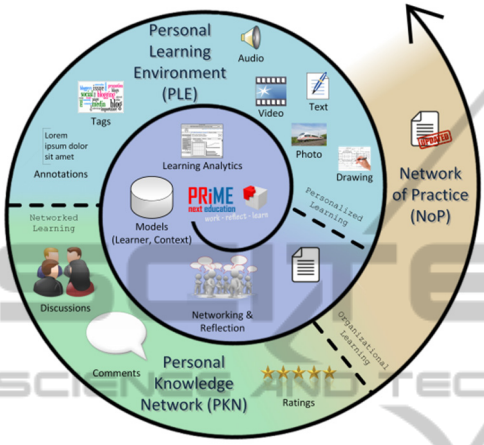


Figure 3: Continuous Knowledge Networking in PRiME.

## 4.2 Implementation

PRiME provides an integrated learning and work platform through a set of Web and mobile applications to support continuous knowledge networking at the three different layers. The platform can be used in any organizational setting. Mobile professional learners represent the primary target group of PRiME. As a proof of concept, we addressed in this work service technicians at Deutsche Bahn as a possible target group. These include car inspectors, specialist authors, training developers, and trainers working in the field of car inspection service. The car inspector is a mechanic that performs rail-worthiness checks on trains. He repairs small-scale damages on trains and decides about trains' dispositions on extensive problems. The specialist author is responsible for the creation of new learning resources. The training developers are responsible for the selection, aggregation, and creation of trainings from existing learning materials created by specialist authors. The trainers are responsible for the organization and execution of the professional technical trainings and workshops with car inspectors. They use the learning materials prepared by training developers.

The document base in the PRiME platform consists of existing company documents, such as guidelines and instruction rules. The majority of such documents are already available in a digital form, e.g. as Word, PowerPoint or PDF. Through a Web-based application, called the *Bundler* (see Figure 1), these documents are imported into the PRiME system, processed according to their hierarchical logical structure, and stored in a tree-like structure. Specialist authors can use the *Bundler* to upload their documents, which can be automatically processed to fit the PRiME data schema which consists of so-called *Snippets* and *Bundles*. Snippets represent atomic learning units that can take the form of text, table, image, audio, or video. Bundles are used to structure such snippets. Each bundle can hold several snippets and also several sub-bundles. The bundles can be seen as the structure of sections in a book, whereas the snippets are the content of a book. Whenever possible, additional information, such as the name of the author, keywords, or other metadata, is also extracted from the uploaded document. After this initial step, the document is presented in its tree-like structure of bundles and snippets to the specialist author who can manually alter the automatically generated result by splitting and merging single elements. When the author is satisfied with the result, the initial version of this document is released to the PRiME system as a set of bundles and snippets which can be used by car inspectors as learning resources and reused by training developers and trainers as building blocks for training and workshop materials.

The *Bundler* can further be used by training developers to mash up and create own bundles from existing bundles and snippets in the PRiME system according to their needs (see Figure 4). Thereby, the training developers can search for already existing snippets. Different filters and search criteria help to limit the search results to only show context-relevant snippets. In the left column of the screenshot, a tree-like view helps to easily structure and arrange snippets at various levels of a new bundle with simple drag and drop actions. The right column shows a document-like view of the aggregated bundle. The new bundle is then published and can be used by trainers in their workshops and subscribed to by the car inspectors who are interested in it. The *Bundler* further offers different export modules that allow the trainer to convert bundles to traditional formats, such as pdf, word, PowerPoint that can be used as handouts in the workshop.

In addition to converting an existing document to snippets, and mixing up existing snippets to new bundles, the specialist author may also use the

*Bundler* application to create snippets and bundles from scratch.

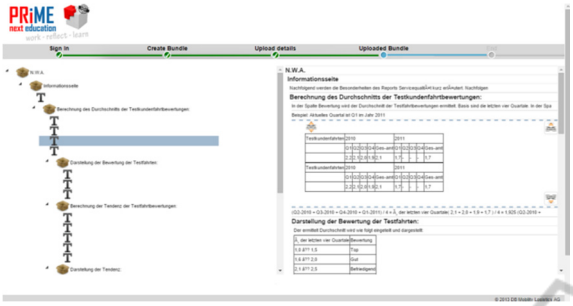

Figure 4: Bundler: Existing documents are imported and processed in the PRiME system.

In PRiME, learning is a continuous process which involves the learners, their personal networks, and the organization itself. PRiME divides the learning and working process into three layers, namely the Personal Learning Environment (PLE), the Personal Knowledge Network (PKN), and the Network of Practice (NoP). In the following sections, we discuss in detail the work and learning activities in relation to each layer and how these activities are supported by the PRiME tool set.

### 4.2.1 Personal Learning Environment (PLE)

A Personal Learning Environment (PLE) enables professional learners to compile their own individual knowledge assets which are relevant for their everyday working context. Each learner decides on her own, which information is important for solving daily tasks and for improving one's knowledge. The task of a mobile PLE is to support the learners in their everyday life, either for solving current tasks and problems or for learning in context. Knowledge assets in the PRiME system include bundles, snippets, and annotations. An annotation is multimedia information created by the learner, which can either be attached to bundles and snippets or detached from those structures.

In a PLE, a learner should not only be able to define which information is available but also how the learning environment should look like. One possibility to achieve this is to implement one monolithic application with all the required functionalities and various options for the learner to adjust everything. In the PRiME system, we opted for a set of applications where each application is responsible for a single task. All PRiME applications are able to communicate with each other and to share functionalities. By selecting the own set of applications, the learner also decides how the own learning environment looks like. The starting point for all the PRiME applications on the learner's mobile device is the *Dashboard* (see Figure 5). It encapsulates all the functionalities by displaying each PRiME application and by providing a centralized communication system for all the installed applications in the PRiME ecosystem.


Figure 5: The Dashboard is the main entry point to the PRiME ecosystem.

With the help of the application *BundleReader* (see Figure 6), a car inspector is able to subscribe to, create, and display her own set of bundles and snippets that are required for her work. Alongside, she can also create her own multimedia annotation for each bundle or snippet available in the application. For displaying additional information for one bundle or snippet, the user has to swipe a bar from the right border to the center. This newly opened area contains all the metadata about the currently highlighted bundle or snippet, namely the author, the version, the date of last change, as well as public annotations and comments. Annotations are questions and corrections to a bundle or snippet that offer the possibility to capture knowledge during the work process. Instead of taking a note on a loose sheet of paper which normally gets lost, car inspectors can take a photo of a machine or record a short video of a procedure. In general, annotations cover various types of multimedia (e.g. text, image, audio, video, or drawing) which can be created very easy and they provide a great expressiveness at the same time. To create a new personal annotation, a user can just tap the toolbox in the upper right corner and select the type of annotation to be added. The newly created annotation will appear on the right side of the application, associated with the bundle or snippet it has been created for. Annotations are context-sensitive and can be extended automatically with meta-information, such as recording time or location. At first, they are strictly personal and not

visible to any other user. Thus, they can hold some personal work instructions that are helpful for future tasks. Furthermore, the car inspector can use the intelligent search functionality provided by the *BundleReader* to discover context-relevant bundles. For example, some knowledge is location-based due to machinery, or physical conditions such as noise might result in exclusion of media types containing audio. The search result can further be filtered according to author, topic, keywords, time, location, etc.

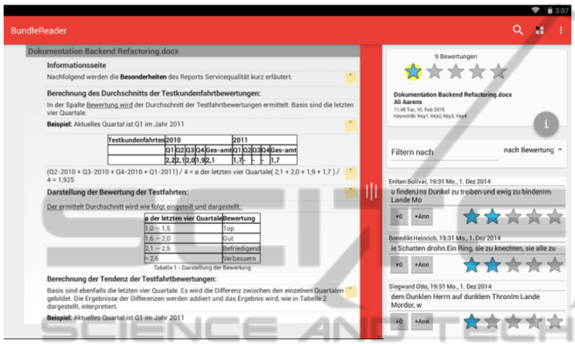


Figure 6: The BundleReader enables learners to subscribe to, display and annotate bundles and snippets.

Car inspectors at work often do not have the time to write extensive annotations and link them to a specific bundle or snippet. The application *Notepad* was developed to support car inspectors in taking quick notes in form of text, picture, video, audio, or drawing which can be used for self-reflection after work or as basis for annotations on bundles and snippets in the *BundleReader*. For example, while reading a snippet, the car inspector might remember that she took a picture which can clarify the instructions given in the snippet and use the picture as annotation for that snippet.

Figure 7 shows the *Notepad* application. A new note can easily be created by tapping the red button in the lower right side of the application. A new menu appears where the car inspector can select which kind of note she wants to create. In addition to the note itself, keywords, short comments and other meta information, such as time and location can be added optionally. This simplifies the process of finding the correct note when needed. Selection from storage like SD card is possible as well as using the device-internal tools to record multimedia like the camera application. A personal media gallery collects all the created notes. The car inspector can define when to synchronize them with a server-side personal repository.


Figure 7: The Notepad enables learners to quickly take notes in their PLE.

### 4.2.2 Personal Knowledge Network (PKN)

The Personal Knowledge Network (PKN) layer fosters continuous networking and collaborative knowledge creation. It enables professional learners to share tips and tricks and collaboratively work on the constant improvement of the available knowledge assets.

As mentioned in the previous section, at the PLE layer, a car inspector can use the *BundleReader* to make annotations on the bundles and snippets she has subscribed to and keep them private per default. If she decides that her personal annotations are worth sharing, she can publish them to all other subscribers or share them with selected peers or groups that can be personally defined. Annotations can then be seen by all recipients who can give ratings and might reply to these annotations with their own ones. This way, expert discussions can emerge resulting in collaborative creation and maturing of knowledge. Car inspectors who apply the knowledge in their daily tasks have thus the possibility to give valuable feedback to aid the specialist authors in improving the produced bundles and snippets.

As the available knowledge is rapidly growing and updates in the system are hard to track, PRiME users should have an easy way to stay up to date without being overwhelmed with the constant flow of information. This is achieved through the native mobile application *Newsstream* which provides an aggregated view of recent activities in the PRiME system, as shown in Figure 8. Car inspectors, specialist authors, training developers, and trainers who subscribed to a specific bundle continuously receive notifications on the annotations, ratings, and changes made to the bundle. By clicking on a notification, they are directly forwarded to the respective bundle, snippet, or annotation in the *BundleReader*. Car inspectors can follow the discussion and rating activities on the bundle or

snippet they are interested in and discover quality annotations contributed by peers. They can also set filters so that e.g. only notifications related to a specific snippet or given by a specific peer are displayed. Furthermore, they can use the *Newsstream* to receive recommendations according to their preferences and activities in the system. On the other hand, specialist authors, training developers, and trainers can get continuous feedback that can be used in the enhancement of their snippets and bundles.

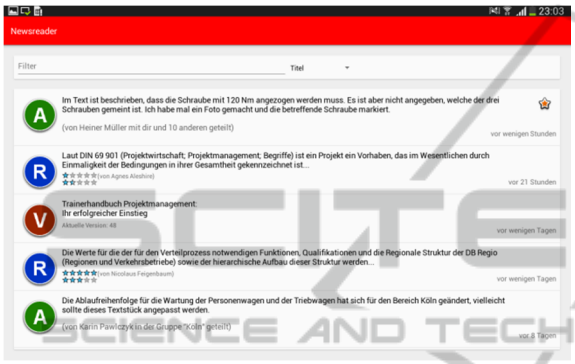


Figure 8: The Newsreader provides an aggregated view of recent activities.

### 4.2.3 Network of Practice (NoP)

The Network of Practice (NoP) represents the organization layer in PRiME. It supports the propagation of the knowledge created at the PLE and PKN layers to the entire organization. The NoP layer harnesses the collective intelligence to ensure that the organizational knowledge is accurate and up to date. An organization represents a knowledge ecology. Organizational learning occurs when individuals within an organization experience a problem and work on solving this problem. This happens through a continuous process of organizational inquiry, where everyone in the organizational environment can inquire, test, compare and adjust her knowledge, which is a private image of the organizational knowledge. Effective organizational inquiry then leads to an update of one's knowledge, thereby updating the organizational knowledge.

The knowledge which is available in PRiME can be continuously improved with every action in the system. At the PKN layer, the collective intelligence decides which knowledge is of high quality through commenting and rating. Quality knowledge that emerges as a result of the continuous interaction between PRiME users at the PKN layer builds the cornerstone for the enhancement of the organization-wide knowledge assets. When a new annotation to a snippet at the PKN layer is highly rated, the specialist author is notified and can use this annotation for the enhancement of the snippet. Training developers and trainers can use the improved snippet in their trainings and workshops. Car inspectors who subscribed to this snippet will automatically get notified about this update. The whole process starts then anew at the PLE layer. This continuous knowledge networking process ensures an effective individual and organizational learning.

## 5 CONCLUSIONS AND FUTURE WORK

Technology Enhanced Learning (TEL) in professional and organizational settings is increasingly gaining importance. In this paper, we addressed the challenge of convergence of professional learning and knowledge management (KM). Driven by the learning as a network (LaaN) theory, which presents a new perspective characterized by the convergence of learning and work within a learner-centric knowledge environment, we discussed the conceptual and implementation details of the Professional Reflective Mobile Personal Learning Environments (PRiME) project. PRiME fosters knowledge in action and provides a new vision of learning at the workplace defined by the seamless integration of TEL and KM concepts into one solution toward a new model of professional learning in context. Learning in PRiME is the result of continuous knowledge networking at three layers, namely personal learning environment (PLE), personal knowledge network (PKN), and network of practice (NoP). Different mobile applications have been introduced to support the various activities related to each of these layers.

We had a series of workshops with potential PRiME users at Deutsche Bahn in which we collected requirements and discussed early prototypes of the different applications. We plan to perform an empirical study of our approach, which will allow us to thoroughly evaluate the usability of the developed applications as well as the effectiveness of our method to support work-integrated networked learning. Besides extending the PRiME application ecosystem, future work will also include the implementation of personal dashboards to support self-reflection and awareness, as well as different learning analytics methods that

leverages the context information to provide effective recommendation and intelligent feedback to PRiME users.

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