

Context-Aware Mobile Professional Learning in PRiME

Christoph Greven, Mohamed Amine Chatti, Hendrik Thüs, Ulrik Schroeder

Learning Technologies Research Group
RWTH Aachen University
Ahornstraße 55
52074 Aachen

{greven, chatti, thues, schroeder}@cs.rwth-aachen.de

Abstract. Technology Enhanced Learning (TEL) in professional and organizational settings is increasingly gaining importance. The high availability of mobile end devices and their ability to support learning across contexts open up new perspectives for effective professional learning and knowledge management. The BMBF project Professional Reflective Mobile Personal Learning Environments (PRiME) addresses the challenge of mobile learning in context and realizes a seamless learning framework which connects learning and work processes. PRiME enables the mobile professional learner to harness implicit knowledge and supports continuous knowledge creation and reflection at three different layers: the personal learning environment (PLE), the personal knowledge network (PKN), and the network of practice (NoP).

Keywords: mobile learning, professional learning, knowledge management, context, reflection

1 Introduction

The widespread use of mobile technologies has led to an increasing interest in mobile learning. Mobile learning can be seen as a subset of technology-enhanced learning (TEL) that includes the usage of mobile devices to enable learning anywhere and at any time. Mobile learning is thus an interaction or activity of an individual which uses a mobile device, capable of having a reliable connection to communicate with a mobile learning platform, with the main goal to consume or create knowledge. Context is a central topic of research in that area. In fact, a major benefit of mobile devices is that they enable learning across contexts. Context-aware mobile learning applications leverage the context information of the learner to provide personalized and motivating learning experiences. Context-aware learning is increasingly important at the workplace, where learning is normally done on-the-fly; this means it is very fast and mostly integrated in the work process.

Several researchers have proposed theoretical work around mobile learning and proposed models on how to leverage emerging mobile technologies in teaching and learning (Koole, 2009; Park, 2011; Sharples, Taylor and Vavoula, 2010). However,

comparatively little research has been done to focus on the context attribute in mobile learning at the workplace and only few research on context-aware mobile professional learning exist. In this paper, we present the conceptual and first implementation details of the Professional Reflective Mobile Personal Learning Environments (PRiME) project. PRiME provides a new vision of learning at the workplace defined by the seamless integration of mobile learning and knowledge management concepts into one solution toward a new model of mobile professional learning in context. In PRiME, learning is no longer regarded as an external training activity separate from the work flow, but rather as a learner-controlled evolving activity embedded directly into work processes.

The remainder of this paper is structured as follows. Section 2 gives an introduction to the term mobile learning in context. In Section 3, we address the relationship between professional learning and knowledge management. Section 4 presents the conceptual and implementation details of PRiME. Finally, section 6 gives a summary of the main results of the paper and outlines perspectives for future work.

2 Mobile Learning in Context

It has been widely recognized that context is one of the most distinctive features in mobile learning (Specht, 2009; Wang, 2004). The term context-aware was brought and defined by Schilit et al. (1994) to describe the location, identities of nearby people, objects and changes to objects. A very popular definition is given by Dey (2001, p. 5) who defines context as "... any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between the user and the application, including the user and the applications themselves". According to Dey et al. (2001), there are three types of information that need to be gathered to describe any specific context - places, people and things. Specht et al. (2011) view context as any kind of information to determine, specify, or clarify the meaning of an event.

Context can be categorized into two types: extrinsic and intrinsic context. The extrinsic context deals with the user's current state of the environment. It may be the user's current position, the time of the day or the interval in which the user learns, or the object the user currently deals with and how this information can support his learning. It may also contain the relation to learners which was described by Costa et al. (2006). Intrinsic context information deals with the inside of a user. For Costa et al., "intrinsic context information inheres in a single entity" (2006, p. 3), an entity can either be a device or a person. This context information contains for example the user's level of attention or the level of motivation.

Harnessing context in a mobile learning experience has a wide range of benefits including personalization, adaptation, intelligent feedback, and recommendation. Adding context information to a set of applications may lead to presenting more personalized data to the learner and to more personalized applications. Context may contain information about the current situation, in which the learner is in, his or her pace, the pre-knowledge, interest, peers, motivation, etc. Context-aware mobile learning

applications leverage this context information of the learner to provide personalized and motivating learning experiences.

As mobile devices are becoming ubiquitous and the workplace is increasingly mobile, there is an interest in the educational applications of mobile technologies in a professional learning context. Mobile professional learning refers to the use of mobile devices at the workplace for the purpose of learning while on the move.

3 Professional Learning and Knowledge Management

In an organizational environment, professional learning and knowledge management have attracted attention over the past years and are meanwhile important tasks to increase competitive advantages of an organization. In practice, however, the two fields have evolved down separate paths. While knowledge management concentrates on knowledge collection and distribution, professional learning focuses on formal learning and training of the employees. This tightened perspective can still be read from today's companies' organizations. Knowledge management and professional learning are commonly related to two different departments, namely IT and human resources.

Over the past few years, companies and researchers are starting to recognize relationships and intersections between the two fields and to explore the potential and benefits of their integration (Dunn and Iliff, 2005; Grace and Butler, 2005; Hall, 2001) 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 professional learning and knowledge management. LaaN starts from the learner and views learning as the continuous creation of a Personal Knowledge Network (PKN). In LaaN, a knowledge worker is a lifelong learner who is continuously creating and optimizing her PKN. 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. 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.

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 German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung - BMBF) with a runtime of three years, finishing in June 2016.

PRiME draws together the concepts behind the LaaN theory and context-aware mobile learning. It provides a framework for the integration of professional learning and knowledge management within a mobile learning and working environment. The learning process in PRiME is a spiral and cyclic conversion of individual and organizational learning at three different levels of knowledge creation and reflection.

PRiME addresses the following objectives:

- Provide an innovative professional learning approach, where informal and network learning converge around a self-directed learning environment. This approach is grounded in the Learning as a Network (LaaN) theory.
- 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 creation 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 new 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.

4.1 Scenarios

Mobile professional learners represent the primary target group of PRiME. As a proof of concept, we addressed service technicians at Deutsche Bahn as a possible target group. These include car inspectors and the corresponding training developers, trainers, and specialist authors working in the field of car inspection service of the long-distance passenger transport DB Fernverkehr AG. In the following sections, the different occupational images and areas of activities as well as possible scenarios are explained in some detail.

Car Inspector.

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. Either he works in a marshaling yard where trains are parked on holding tracks until their next usage or he attends a train on duty to ensure a smooth production flow. A car inspector is normally on his own after he got some work instructions when beginning his working shift. The field of work covers various different technical systems and machines and hence a lot of expertise and knowledge is required. Being an all-rounder, he has to master different tasks, such as handling newest and very old models, common and extraordinary procedures, and domestic and for-

eign machinery. In order to take accurate decisions in specific work contexts, either he has the required knowledge or he has to refer to related materials. Due to the complexity of knowledge that has to be acquired, remembering all needed details is impossible. On the other hand, getting access to auxiliary material is not really realizable due to the non-manageable physical amount of material, normally available as hardcopies. The following use case describes a possible flow of workflow of a car inspector with PRiME support.

Carl, being part of the car inspection service team, is using the PRiME system. He has access to the learning materials (called bundles in PRiME) from a workshop he attended recently. The bundles are covering knowledge assets regarding his field of application that has been created by a training developer. Furthermore, Carl searches the system for some bundles that might be useful for his next working day when he will need to deal with a specific machine. He finds several matching bundles that he subscribes to in order to receive changes and news related to these bundles. Carl faces a problem while he is on the field to repair a machine. He checks the related bundles as they are also available offline on his tablet. He finds a small learning unit (called snippet in PRiME) that might assist him with his current problem and follows the instructions provided in the snippet. While repairing the machine, Carl comes up with a new solution. He uses the video camera of his tablet to record the process. He then extends the related snippet with the captured video as annotation and saves it for future use. Whenever he is using the snippet again he gets his annotation associated with it. Back in his office, Carl enhances his annotation with some more information explaining the steps of his new solution in more details. He then shares his annotation with his colleagues who also subscribed to the same bundle. They are informed about the new annotation via a personalized aggregation interface (called *Newsstream* in PRiME). Carl's contribution further initiates a discussion and his colleagues start to post comments and other annotations related to the same snippet. Some colleagues consider Carl's annotation to be very helpful and give it a very good rating. Carl himself is also informed about those activities in his *Newsstream* and he is glad that he could help his colleagues. Some weeks later the specialist author who published the snippet became aware of Carl's highly rated solution and asks him for his permission to implement it in a new version of the snippet. All the bundles which contain the enhanced snippet will be updated. The updated bundles are then communicated to all subscribers through their *Newsstreams*. Carl's contribution is now part of the organizational-wide learning materials.

Specialist Author.

The specialist author is responsible for the creation of new learning resources. Doris is a specialist author. She creates guidelines, instruction rules related to car inspections. She uses the PRiME *Snippet Creator* as an authoring tool to easily create multimedia (text, image, audio, or video) learning units. These snippets then be stored in the PRiME system and can be used by training developers as backbones for trainings and workshops (refer to the training developer scenario). Moreover, Doris uses the PRiME *Snippeteter* to automatically convert an existing Word document containing working instructions to a set of snippets.

Training Developer.

As compared to the car inspectors and the specialist authors, training developers are not technical experts and belong to another department at Deutsche Bahn AG. The training developers are responsible for the selection, aggregation, and creation of trainings from existing learning materials (bundles) created by specialist authors. Corinna is a training developer. She uses the PRiME system to create bundles that may be used in workshops or trainings. She got the task to prepare new bundles to be used by a trainer in a workshop with car inspectors. Corinna uses a PRiME authoring tool (*Bundler*) to search, filter, and aggregate existing bundles and snippets to create a new bundle. She also reuses parts of bundles she created in a previous work. The PRiME *Bundler* enables Corinna to easily structure and arrange content in her new bundle with simple drag and drop actions. When she finishes, the new bundle is published and can be used by the trainer in the workshop and subscribed to by the car inspectors who are interested in it. Corinna is informed as soon as someone rates or comments on her bundle. She also receives feedback from the trainer who used her bundle in his workshop. Based on the feedback, she enhances her bundle with further content, rearranges some parts, and deletes content which is not required. Changes of her bundles are again communicated to all subscribers.

Trainer.

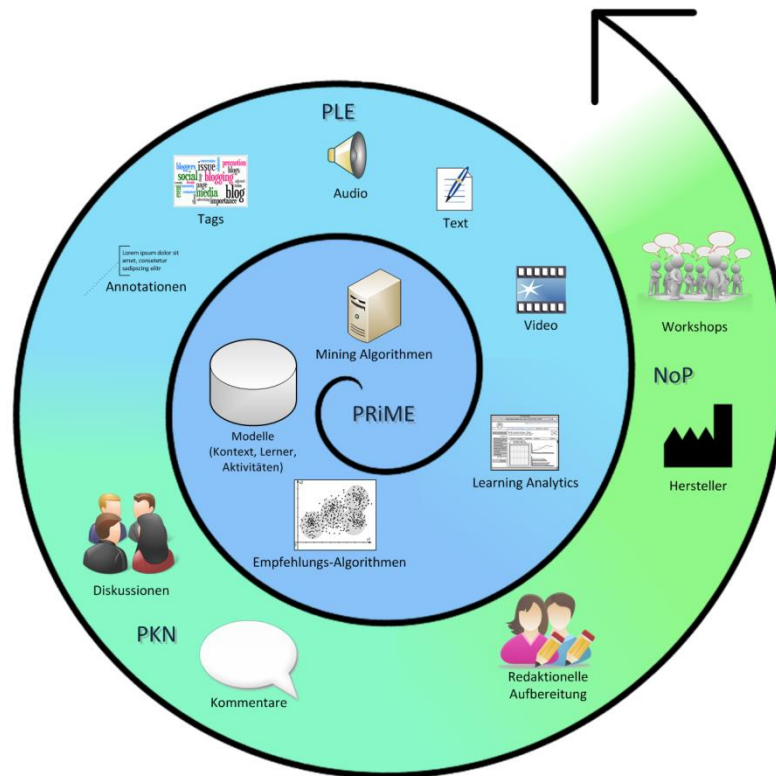
The trainers are responsible for the organization and execution of the professional technical trainings and workshops with the technicians. They use the learning materials (bundles) prepared by the training developers. These trainings are commonly done in traditional face to face classroom settings, often lasting for several days. During that time, participants interrupt their normal work to attend the training. Besides knowledge about the topic, the trainer should have the didactical skills required for an effective training. George is a trainer and is in charge of practical trainings and workshops with car inspectors, covering facilities and techniques of car inspection services. He is asked to arrange a workshop soon addressing the topic maintenance of passenger trains. Therefore, he makes use of the PRiME system to select relevant bundles required for his workshop. The bundles contain different snippets as textual instructions, diagrams, and demonstration videos. With the help of the PRiME export function, George is able to export the bundles as a simple presentation slides. In the workshop, he collects feedback to the bundles and forwards them to the training developer. After the workshop, the car inspectors get access to the bundles and can subscribe to them for continuous learning, as presented in the car inspector scenario.

4.2 Implementation

As presented in the scenarios above, learning and knowledge creation in PRiME is a continuous process involving professional learners, their networks, and the organization. As depicted in Figure 1 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.

Fig. 1.



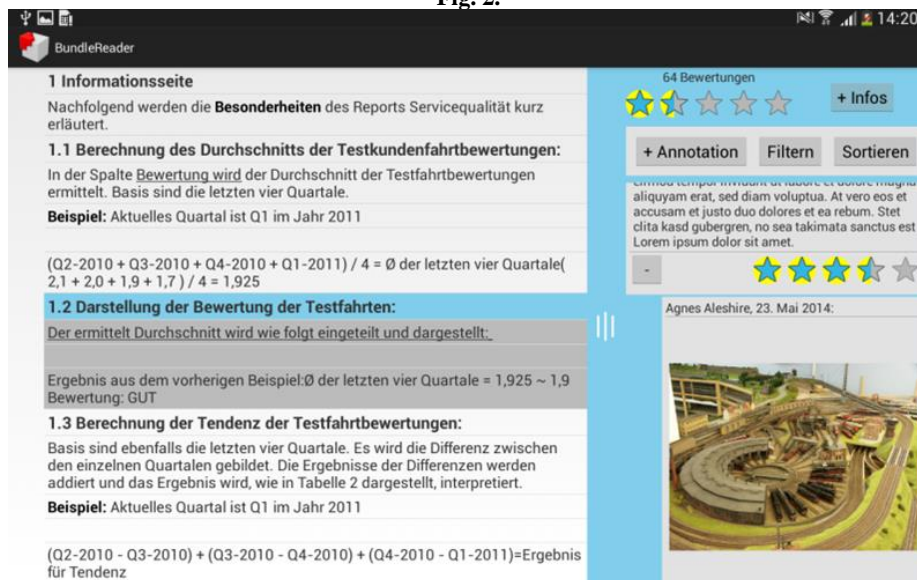
Continuous creation of knowledge in PRiME considering the three reflection layers: Personal Learning Environment (PLE), Personal Knowledge Network (PKN), and Network of Practice (NoP).

Personal Learning Environment (PLE).

The Personal Learning Environment (PLE) represents the knowledge home of the professional learners (in our scenarios car inspectors but also specialist authors, training developers, trainers) enabling them to create their individual learning environments by assembling the knowledge assets which are relevant for their working context. In PRiME, these include bundles, snippets, and private annotations. A snippet is an atomic learning unit that can take the form of a text, image, audio, or video. A bundle is a set of snippets representing a learning material. An annotation is a multimedia enrichment of a snippet or a bundle.

The mobile PLE can be accessed at work at any time to solve current tasks. Car inspectors can use their mobile PLE to search and subscribe to relevant bundles, visualize the content of snippets and bundles, take notes, and make annotation. These activities are supported by a set of native mobile applications. The Android-based application *Reader* enables car inspectors to search for, subscribe to, and annotate bundles. As shown in Figure 2, the left side of the *Reader* visualizes a bundle and its associated snippets. Swiping from the right border fades in a list of annotations available for the selected content on the left. Personal annotations can be added via the buttons at the top of the annotation column and appear at the beginning of the list. Annotations are comments, questions, corrections, etc. to a bundle or snippet that offer the possibility to capture knowledge during the work process. They cover various types of multimedia (text, image, audio, or video) that make the creation very easy and provide a great expressiveness at the same time. 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. Annotations are context-sensitive and can be extended 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 *Reader* 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.

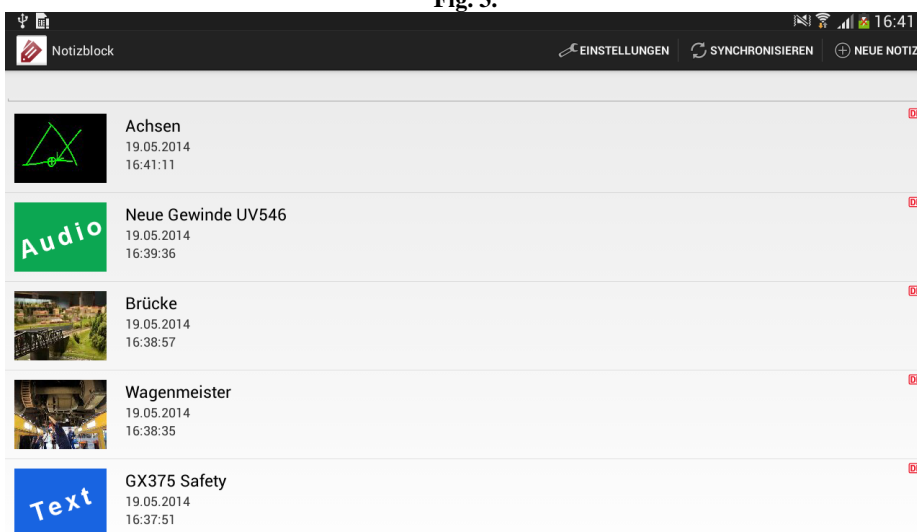
Fig. 2.



Reader application for knowledge access and personal annotations.

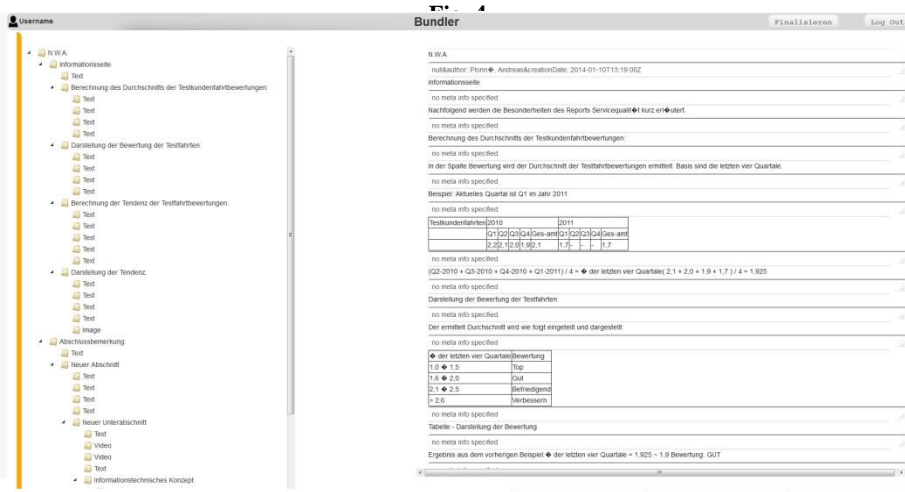
Car inspectors at work often do not have the time to write extensive annotations and link them to a specific snippet or bundle. Instead they can also use the PRiME system to simply take a photo, record a video, write a short text, or create a chart and store it for future use. These notes can then be used as a basis for annotations. A kind of media gallery collects all of the created notes and synchronizes them with a server-sided personal repository. Figure 3 shows the *Notepad* application that is realizing this functionality. The list holds all notes captured by a car inspector with optionally a short comment and keywords. By simply pressing a button in the top right corner new notes can be added. Selection from storage like SD card is possible as well as using the device-internal tools to record multimedia like the camera application.

Fig. 3.



Notepad for fast and easy collection of multimedia.

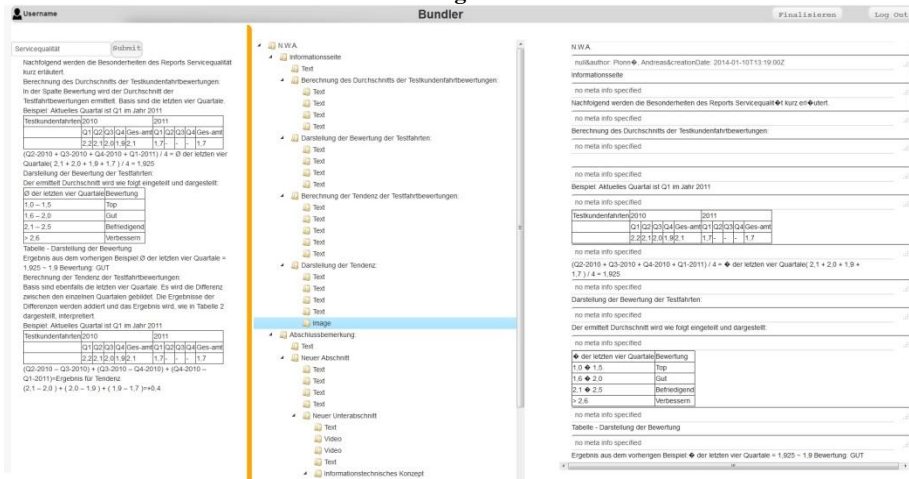
As presented in the scenarios, specialist authors are responsible for creation and maintenance of guidelines and instruction rules. Today, most of such documents are already available in digital formats, e.g. as pdf, word, PowerPoint. The PRiME *Snippeter* Web application offers means to import such documents and automatically convert them to snippets. Figure 4. shows the import of a docx file. After the document has been uploaded, the *Snippeter* splits up the file into snippets and rebuilds its hierarchical logical structure into tree-structured bundles. The resulting bundles are then presented to the specialist author and can be modified. This includes merge and split of snippets. Whenever it is also possible to extract metadata from the source file, these are attached to the generated snippets. If the results are still not satisfactory, the specialist author may add metadata manually via the *Snippeter* interface. When the import is done, an initial version of the document is available in PRiME as a bundle. In addition to converting an existing document to snippets, the specialist author may use the *Snippet Creator* Web application to create snippets from scratch.



Snippets after importing a docx file into PRiME.

The snippets created by the Specialist author build the backbone for bundles that a training developer can compose for a specific training or workshop. Their primary tool is the *Bundler* Web application to aggregate and edit bundles. The functionalities of a *Bundler* are shown in Figure 5. The left column is used to search for already existing snippets. Different filters and search criteria help to limit the search results to only show context-relevant snippets. In the middle column, a tree-like view helps to structure and arrange snippets at various bundle levels. Simple drag and drop actions can be used to include search results from the left column into the bundle tree. The right column shows a document-like view of the aggregated bundle.

Fig. 5.

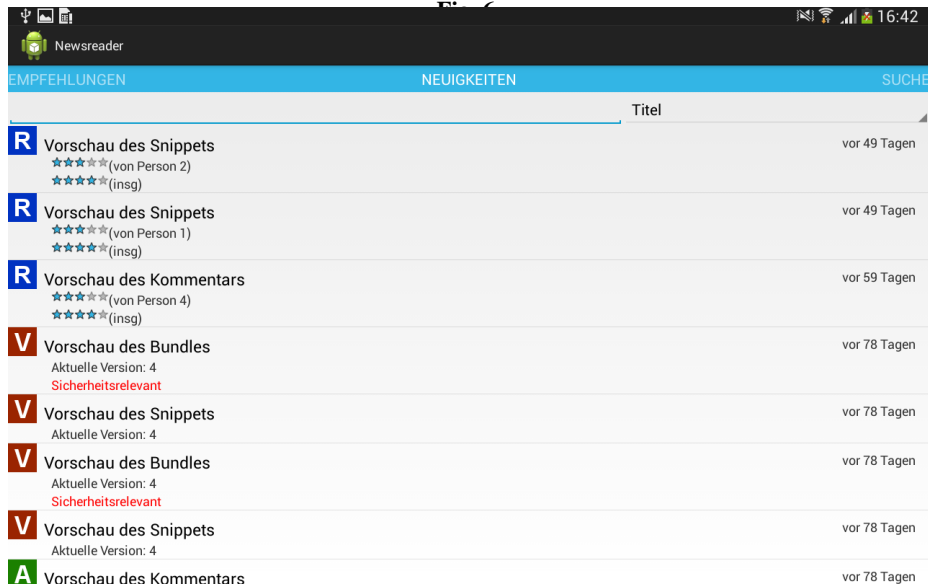


Bundler to create and arrange new, reusable knowledge bundles.

The *Bundler* can also be used by the trainer to search for relevant pre-assembled bundles for his training or workshop. 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.

Personal Knowledge Network (PKN).

The Personal Knowledge Network (PKN) represents the networking layer in PRiME. This layer supports sharing and interaction with selected peers, thus enabling collaborative knowledge creation. In the case of car inspectors, previously taken personal annotations in the *Reader* can be shared with selected peers or groups that can be personally defined. Annotations can then be seen by all members of the publishing group 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 the possibility to give valuable feedback to aid the specialist authors in improving the produced snippets. Because over time the available knowledge is rapidly growing, recognizing changes in the system becomes harder. In PRiME, 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. Car inspectors can follow the discussion and discover quality snippets/bundles. Specialist authors, training developers, and trainers can get continuous feedback that can be used in the enhancement of their snippets or bundles. This is achieved through the native Android-based *Newsstream* application which provides an aggregated view of recent activities, as shown in Figure 6. Furthermore, car inspectors use the *Newsstream* to receive recommendations according to their preference and activities in the system.



Newsstream informing about activities related to favored knowledge.

Network of Practice (NoP).

The Network of Practice (NoP) represents the organization layer in PRiME. This layer supports the propagation of the knowledge created at the personal network level to the entire organization. Quality knowledge that emerges as a result of the continuous interaction between all PRiME users at the PKN level builds the cornerstone for the enhancement of the organization-wide guidelines and instructions rules. The specialist author can use the highly rated annotations as a base for new snippets or versions of the same. For this he uses the *Snippet Creator*. The training developer and the trainer can use the *Bundler* for the creation of new bundles to be used in the next trainings and workshops. This continuous knowledge creation and reflection process ensures that the organization knowledge is accurate and up to date.

The following table summarizes the mapping of the different roles and most important functionalities of the PRiME toolkit to the three reflection layers, namely PLE, PKN, and NoP.

Table 1. Mapping roles, functionalities, and reflection layers in PRiME.

	PLE	PKN	NoP
Car inspector	Multimedia data collection ¹ , knowledge access ² , offline availability ² , personal annotations ²	Subscription ⁴ , sharing of annotations ² , receiving annotation ² , rating ² , news aggregation ⁴ , receive recommendations ⁴	
Specialist author	Data import ⁵ , content processing ³ , content creation ⁶	Subscription ⁴ , discovery of need for changes ⁴ , receive feedback ²	rework content (snippets) ⁶ , Publication ⁶
Training developer	Content search and filtering ³ , content aggregation ³	Subscription ⁴ , receive feedback ²	rework content (bundles) ³ , Publication ³
Trainer	Content search and filtering ³ , data export ⁷	Subscription ⁴ , give feedback ² , receive feedback ²	Rework training ³

¹Notepad, ²Reader, ³Bundler, ⁴Newsstream, ⁵Snippeter, ⁶Snippet Creator, ⁷Exporter

5 Conclusion and Future Work

In this paper, we addressed the challenges of mobile learning in context as well as the convergence of professional learning and knowledge management. We presented the theoretical, conceptual, and implementational details of the Professional Reflective Mobile Personal Learning Environments (PRiME). The main goal of PRiME is to offer seamless learning across times, locations, and social contexts combining the work and learning processes into one. Learning in PRiME is the result of a continuous knowledge creation and reflection 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. The project is still in the first phase of development. Hence, comprehensive evaluations are not yet possible. So far, the applications cover basic functionalities but will be continuously extended and incorporate context such as social connections as friends or colleagues, learning time or behavior, physical environment, etc. Thus, future work will 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 the PRiME users.

References

- Chatti, M. A., Schroeder, U. and Jarke, M. (2012) 'LaaN: Convergence of Knowledge Management and Technology Enhanced Learning', *IEEE Transactions on Learning Technologies*, Vol. 5, No. 2, pp.177–189.
- Costa, P.D., Almeida, J.P.A., Pires, L.F., Guizzardi, G. and van Sinderen, M. (2006) 'Towards conceptual foundations for context-aware applications', Proceedings of the Third International Workshop on Modeling and Retrieval of Context (MRC06).
- Dey, A.K. (2001) 'Understanding and using context', *Personal and Ubiquitous Computing*, Vol. 5, No. 1, pp.4–7.
- Dunn P. and Iliff, M. (2005) 'At Cross Purposes—Why E-Learning and Knowledge Management Dont Get Along', *Learning Light. E-Learning and Knowledge Management*, <http://www.learninglight.eu/Register1/LearningLightE-learningandKnowledgeManagement.pdf>
- Grace, A. and Butler, T. (2005) "Learning Management Systems: A New Beginning in the Management of Learning and Knowledge", *International Journal Knowledge and Learning*, vol. 1, no. 1/2, pp. 12-24.
- Hall, B. (2001) "Learning Management and Knowledge Management: Is the Holy Grail of Integration Close at Hand?" white paper, <http://www.jacqueslecavalier.com/linked/lkmwp-080301.pdf>
- Koole, M.L. (2009) 'A model for framing mobile learning', *Mobile Learning: Transforming the Delivery of Education and Training*, pp. 25–47.
- Park, Y. (2011) 'A pedagogical framework for mobile learning: categorizing educational applications of mobile technologies into four types', *The International Review of Research in Open and Distance Learning*, Vol. 12, No. 2, pp.78–102.
- Schilit, B., Adams, N. and Want, R. (1994) 'Context-aware computing applications', *Mobile Computing Systems and Applications*, 1994. WMCSA 1994. First Workshop, pp.85–90.
- Sharples, M., Taylor, J. and Vavoula, G. (2010) 'A theory of learning for the mobile age', *Medienbildung in neuen Kulturräumen*, pp. 87–99.
- Specht, M. (2009) *Learning in a Technology Enhanced World*, OCE, Maastricht, The Netherlands, pp. 33–34.
- Specht, M., Ternier, S. and Greller, W. (2011) 'Mobile augmented reality for learning: a case study', *Journal of the Research Center for Educational Technology*, Vol. 7, No. 1, pp.117–127.
- Wang, Y.-K. (2004) 'Context awareness and adaptation in mobile learning', *Wireless and Mobile Technologies in Education, 2004. Proceedings of the 2nd IEEE International Workshop*, pp.154–158.