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Mobile Learning with Micro-content: A Framework and Evaluation

Peter A. Bruck
Research Studio Micro-learning and Information Environment; Research Studios Austria Forschungsgesellschaft, Austria
bruck@researchstudio.at

Luvai Motiwalla
Operations & Info Systems Dept, U MASS LOWELL, USA
luvai_motiwalla@uml.edu

Florian Foerster
Research Studio Micro-learning and Information Environment; Research Studios Austria Forschungsgesellschaft, Austria
florian.foerster@researchstudio.at

Abstract

Micro-learning (ML) combines micro-content delivery with a sequence of micro interactions which enable users to learn without information overload. This has the potential to enable better learning results in terms of retention of propositional content. Learners familiar with Web2.0 technologies, like Tweets and SMS, expect a personalized learning solution and the KnowledgePulse (KP) system researched and developed by the RSA FG delivers this in a work context. ML has potential for enhancing mobile learning which has lacked success despite the explosive popularity of mobile devices. This paper presents the micro-learning approach and the KP sytem that delivers micro-content on mobile devices and allows learning anytime, anyplace and any pace. Three case studies of different product stages of KP are reported with 100+ users in three settings. Results show high usage levels and good satisfaction of learners. These preliminary results provide encouraging signs for the further development of micro-learning systems. Future research needs to expand to a much large scale and also develop an evaluation framework which can serve as standard to investigate how micro and mobile learning can be integrated to create more effective learning.

Keywords*:* mobile computing, microlearning, e-learning, learning effectiveness, learning cards, knowledge system, tech learning evaluation

1 Introduction

Mobile devices (or mobiles) have become the fastest growing technology in human history. Numbers of the International Telecommunication Union (ITU) statistics show more than 6 billion mobile phone connections existed at the end of 2011 worldwide and will grow to 12 billion by 2020 (ITU, 2012). Very soon mobiles will outnumber humans living on earth, presumably by 2013. Countries like India and China add about 17 million phones a month in 2012, with penetration rates reaching beyond 240% in some developed countries this year (ITU, 2012). Also, the share of smart phones is increasing rapidly with more than 80% of phones shipped in Central European markets and nearly 95% in the Gulf countries (ITU, 2012).

One reason for this fast growth of mobiles is due to better designs (like iPhone), more computational power, data storage capacity and network speed and reliability. Today mobiles have become ubiquitous and intimate as a wrist watch, always on and attached to people. These trends provide a significant growth potential for mobile application ecosystem. Applications for news, sports, gaming and social media dominate (Parish et al., 2012; Lenhart et al. 2010), with Facebook recently claiming that it is the most widely used mobile application (Bahar, B., 2010). Learning applications, on the other hand, are not very popular. Also, mobile learning is not a priority for the telecom operators. Rather, smart devices are advertised and sold on the promise of life style, ubiquitous connections and high speed internet access (4G+).

Mobile devices provide users with a number of valuable opportunities including personal control and ownership of the learning process (e.g. Wong, 2012; Ally, 2009). In addition, m-learning allows to break the 'uniqueness' of learning: individuals must no longer 'make time' for learning or prepare for it; rather, as the device is generally personally (i.e. not shared with others as often is the case in some working environments) owned and "always" carried, the availability translates into also an ownership of the learning process by students due to this personal one-on-one relationship (Alexander, 2004). Furthermore, learning can also take place within the context of knowledge domains, thereby making learning more effective (Bransford, 2000).

This paper discusses the use of mobiles and other current state-of-market mobile devices (tablet computers) for learning with a focus on micro-learning. Micro-learning pedagogy focuses on short-term and informal learning activities or learning on the job when the learner needs the knowledge to solve a problem (Kovachev, et. al., 2011). Specifically, this research addresses the suitability of mobile devices with the use of

micro-content learning objects whose size suggests a nearly ideal fit between the two. Research Studios Austria Forschungsgesellschaft (RSA FG) has developed micro-learning applications in order to embed learning into the on-going activities of work and everyday life (Bruck, 2005). Micro-learning has been designed to increase the usage of technology in learning by making it more convenient and adapting the e-learning to the fact that users often have considerable difficulty making time for long stretches of learning activity outside dedicated study times and institutional programs of schools, colleges or universities.

2 M-Learning and Micro-learning

Mobiles provide a powerful platform for some forms of learning where individualization (or personalization) of learning content with anytime and anywhere access is critical (Agha & Ayse. 2011). Mobiles provide a one-to-one relationship with its owner, always on, always there, location aware, and personalized (Wong, 2012; Homan & Wood, 2003). The overall growth of mobiles and its pervasiveness has provided an impetus for research in mobile (m-) learning (Vinu, et. al., 2011; Ally, 2009; Agnes, 2004). M-learning has numerous definitions. For this paper, we use the m-learning definition of Mobile Learning Network, "The exploitation of ubiquitous handheld technologies, together with wireless and mobile phone networks, to facilitate, support, enhance and extend the reach of teaching and learning" (MoLeNET, 2010).

Literature shows that the anytime and anyplace learning opportunity of mobiles provides several benefits for the learning environment like allowing learners and instructors to utilize their spare time while traveling to finish their homework or lesson preparation (Virvou & Alepis, 2005). Another benefit which is stressed is the provision of just-in-time learning (Cornell, R., 2002), for example assisting learners when they are solving a problem and seeking knowledge. M-learning can better cater the learners' need for learning in situations of limited time (e.g. while traveling from and to work) or real time (e.g. while solving a problem at work). Examples include technicians confronted with equipment never seen before: instead of heading back to the office to try to find the relevant documentation, they can use the phone to carry out a visual search, thus retrieving the relevant documentation for the item. In part this can be automated by scanning a device's serial number or similar.

Despite its potential to impact learning environment, m-learning is still in early development stages with both technological and pedagogical limitations (Agha & Ayse, 2011; Motiwalla, 2007). Earlier arguments made in the business world on how mobiles can change work environment by converting worker dead-time (like waiting at airports or in public transportation) into a productive activity (BenMoussa, 2003). However, mobile device limitations such as small screen-size, variations in platforms, mobile networks, and presentation of information to the device in a reliable and friendly manner have been identified by researchers as blocking the uptake of learning usage (Seong & Broga, 2006).

Micro-learning seeks to address some of these "blockers" and to develop a form of content delivery and user interaction which could improve on m-learning usability. Delivering contents in long learning sequences and large chunks of information with low degrees of interactivity have limited the potential of m-learning. Instead, micro-learning breaks m-learning content into small "chunks" with a high level of interaction and instant feedback after each user action. Learning in smaller chunks has support from learning psychology and short-term memory literature (Simon, 1974; Lowenstein, 1994; Cowen, 2011) as well as it jives well with the recent trend of communicating with short messages SMS and Tweets (Holotescu & Grosseck, 2011).

The basic notion of micro-learning is that people can learn better and more effectively when the content is broken down into digestible parts and learning thus takes the form of small steps (Simon, 1974). This is based on human cognition theory which places the limits of processing information in short-term memory (Cowan, 2001). This temporal dimension, learning in small steps better fits into the human processor model of receiving information or knowledge in small homogeneous chunks (Simon, 1974) and fits well in the small screen size of mobile devices (Robes, 2009; Hartson & Hiks, 1989). Micro-learning does not demand separate learning sessions but is integrated into other activities of the learner. Also, micro-learning is good for some types of learning environment where content can be designed in smaller objects, just-in-time learning, and Web 2.0 learning. It may not appropriate of all forms of learning and therefore, it compliments (does not replace) other forms of learning.

In this paper we discuss the impact of micro-learning on the learner based on the preliminary studies and analyses of three use cases with Knowledge Pulse (KP) system and plans for more extensive research in the near future on impact and effectiveness of the ML system. The objective is to leverage the popularity of mobile personal computing devices and successfully address the growing need for effective learning solutions.

3 Micro-learning Approach to Technology Enhanced Learning

Micro-learning has great potential for learning on mobiles. Many Web 2.0 applications offer content in small chunks: short messages, micro-websites, blogs, wikis, podcasts, and news apps. Twitter is probably the most prominent example. Leene (2006) views micro-content learning as focused, self-contained, indivisible, structured and addressable content. It integrates different forms of media in short form: text, video, audio, interactive element used as micro media in fragmented time (Zhang & Ren, 2011).

KP delivers learning content in smaller chunks via digital learning cards which map well with the small screens of mobile or smart phones, with embedded interactive assessments like true/false, matching and others with instant feedback. The learner interactions with the KP transform the m-learning experience to create a continuous

"flow" which in-turn improve knowledge retention and user satisfaction. It is designed and developed to push digital learning cards onto any Internet connected device, be it a PC, notebook computer, tablet or a mobile smartphone. The connection to the application and the short user explanation of how it works are shown in Figure 1. RSA FG has developed KP from a research prototype to a marketable product which is sold as micro-learning system to corporations, public administrations, training providers or professional certification agencies and institutions.

The micro-learning approach utilized by KnowledgePulse (KP) can be differentiated from other forms of micro-learning in three ways: a) use of learning cards which context fields, b) focus on memorization of propositional content c) use of a personalising learning algorithm tracking the user responses (Bruck, 2006; Bruck & Lindner, 2008). Lindner (2007) has similar argued that this form is in line with Web 2.0 developments such as blogs, short text messages, etc.

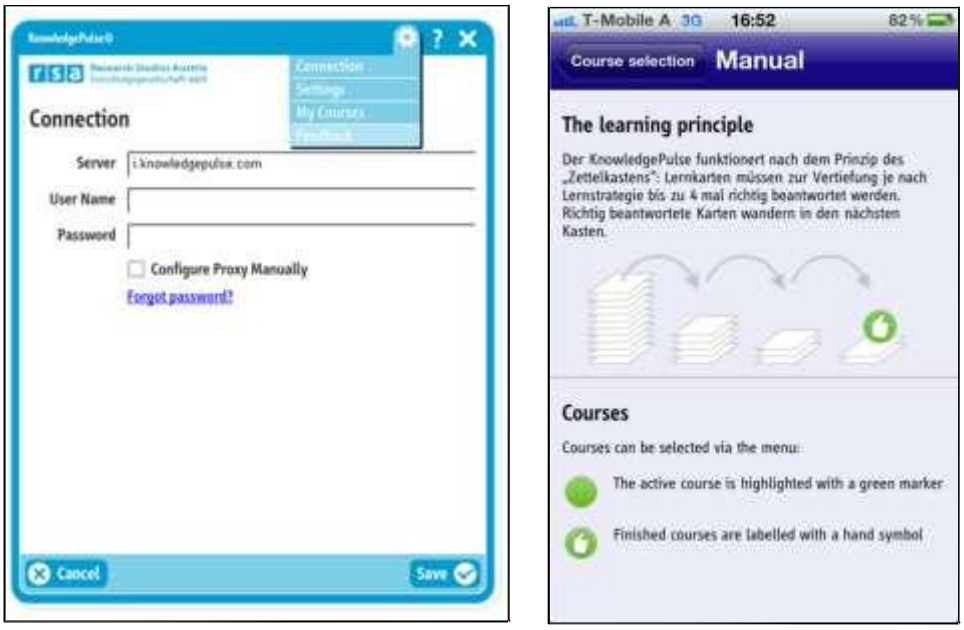

Figure 1: Screenshots of the KP connection for Windows PC (left) and KP explanation for iPhone (right)

When comparing it to traditional forms of technology enhanced learning (referred here as "e-learning"), micro-learning can be distinguished by three aspects: (1) a reduction of volume learning content and an avoidance of a possible overflow of information by structuring content into small units, (2) re-design of learning processes and environments according to the paradigm of small learning units, and (3) empowerment of the learner to choose time, place and pace of learning with personalised learning (Bruck, 2005). Considering these three aspects, Robes (2009) argues that ML is driven by three factors: technological innovation, economic imperatives and cultural practices.

Technologically, the increased usage of smaller computational devices and the availability of mobile communication networks are creating new possibilities for e-learning. The technological innovations created a demand for content that fits the usage patterns of these new technologies. Hence, content is served in the form of small units, fitting to the small screen and context of usage. Economical influences become especially visible in vocational education. Only little time is devoted to training and

learning and longer work breaks for the purpose of learning are becoming an exception. A demand for learning that is seamlessly incorporated into the working routines is becoming more pressing. This cultural shift on content consumption influences how learning materials are designed and delivered. The usage of small learning units is not limited to the size of the learning content, but includes time as a second dimension. Microlearning is learning in small units and within short period of time. Adding up such small units creates what – in classical learning – is seen as lessons and courses.

Regarding the many different forms of learning, microlearning is dedicated to information retention and thus build-up of factual knowledge. Our experience with micro-learning suggests four basic characteristics for its success (Bruck, 2005). These characteristics served as a starting point for designing and developing of micro-learning solutions:

- Repetition of the learning content
- Continuity in repetition activity
- Assessment before progressing to next unit
- Good organisation of content in a manner supporting systematic search of information such as in hierarchies

Micro-learning, especially for informal learning, does not typically separate the learning from knowledge context. KnowledgePulse was designed to be integrated in work routines focusing on smaller learning modules that are delivered continuously, e.g. using moments in between switching two tasks. Learning activity is triggered by the ICT, but within the context of the interaction between user and their moments for learning, triggering more learning.

4 The KnowledgePulse MicroLearning Project

The Research Studios Austria (RSA) started research in the micro-learning area around 2002 and has since designed and developed applications and investigated the impact of micro-content delivery on e-learning. Since 2005, RSA FG has organized an annual scientific conference on this topic dedicated solely to the exchange and development of research and best practices in microlearning.

Besides research on the didactical principles based on microlearning, the main research focus has been on the design, development, testing and implementation of microlearning applications. During the last decade, three generations of assisted learning & information systems for microlearning which are dynamic, flexible and suited to everyday use have been designed and developed by RSA FG. The design was built on the neuro-psychological fundamentals of learning and memorization, the surrounding conditions and requirements for sustainable learning and knowledge build-up in organizations (Bruck, 2006). In addition, we incorporated the needs learners as well as other stakeholders (e.g. trainers, course authors, HR people, IT, management) that were involved during the implementation of microlearning system.

The overall goal of this research project is to make learning easier with micro-content, integrate it in the work environment and provide a more effective learning environment. In the following subsections, we briefly introduce the architectural design of our microlearning system, followed by the presentation of the three generations or stages of

development of our microlearning system, called the KnowledgePulse™. Subsequently, section 5 presents the evaluation work accompanying the development, exemplified by three case studies for each stage of development.

4.1 Architectural Design

The KnowledgePulse™ (KP) micro-learning system was developed by RSA FG on a client-server architecture (see Figure 2).

The KP server can be accessed remotely through a Web browser by a system administrator to (1) create and administrate content, (2) manage users and (3) monitor progress of the learners. It features a content database, an administration interface for users and courses, an authoring tool and a statistical module to visualize the progress of users.

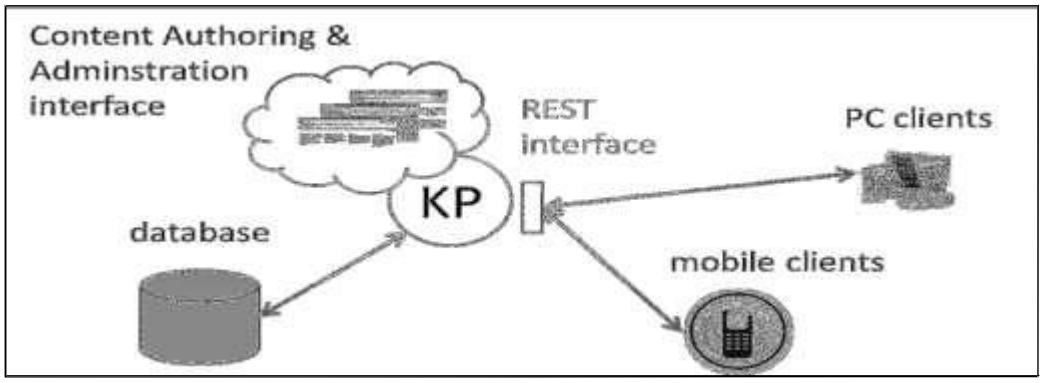

Figure 2: The architecture of the KnowledgePulse system

The server-side employs mathematical algorithms to assess users' progress and adapt the frequency and complexity of the micro-lessons. It serves as a "pacemaker" for learning which adjusts itself to adapt the frequency and complexity of lessons to match each individual's learning ability and progress. It continuously updates each user's profile and re-calibrates the lessons to synchronize them with each user's actual progress. The server was developed in JAVA, using a MYSQL database and a REST interface to the clients.

The clients are the interface for learning to the user, retrieving and presenting the microlearning objects. The implementation of microlearning is based on the idea of flash cards. We used the concept of small learning chunks in steps that can easily repeated. Further data transmission between client and servers involves the learning progress that is synced between the client and the server. The clients guide users through the learning process by present small learning steps according to their learning progress.

Both, server and clients have been developed iteratively following our main design principal of making learning easy (for clients) and similarly making authoring and administration easy. The different stages of development involved both, re-design and evaluation of the server as well as the client interfaces. In the following sections, we will present the three KP clients.

Stage 1: Lernschoner - MicroLearning Through a ScreenSaver

The first generation of the microlearning system used a screensaver interface, called "Lernschoner". It featured context detection provided by operating system's detection of an idle status. Instead of a standard screen saver, an especially screen saver would appear after an indicated amount of time (e.g. 3 minutes) and, present small learning objects. Learner could decide whether to accept the learning impulse or cancel. An example for learning content used was a lesson on how to improve learning vocabulary. In this case, the screen saver would present a phrase. If the user chose to accept the learning step at that moment he would answer the card to himself, followed by clicking on the solution and then comparing his answer with the solution. The user could decide whether or not this learning step was taken successfully. Wrong phrases are repeated until the user answered correctly or quits. This initial version of KP was well integrated into the PC environment and familiar to most users, as a screen saver was a standard tool and only four buttons were presented (Exit and Show solution, and in case of show solution "correct" and "wrong"). This system was very popular with our learners but – being a first prototype - we did not conduct a formal evaluation study involving a high number of participants.

Stage 2: KnowledgePulse - MicroLearning on Windows

The second generation of the microlearning system was characterized by a move to a stand-alone application and added features to customize learning to the needs of the learner. Still based on notion of idle times, using a switch in the context of the user (a short break between the completion of one task and the start of another). For this new generation we introduced the name "KnowledgePulse".

Figure 3: A screenshot of a Multiple Choice / Single Select Learning Card on the KnowledgePulse for Windows

This MicroLearning client (running on Windows XP) allowed us to adapt the time of appearance of learning alerts, selection of the number learning steps and provide

feedback to the trainer. Instead of offering simple vocabulary cards (Simple Question-Answer-Learning Cards) this version included two more forms of learning cards.

1. *Multiple Choice / Single Select Learning Cards:* One question, several sample answers, but only one is the correct choice (see Figure 3).
2. *Multiple Choice / Multiple Select Learning Cards:* These are questions where any number of given answers may be selected.

For all types of learning cards, the system immediately showed which answer(s) were correct plus give the possibilities of adding explanations and further details for each learning card. This KP version was deployed and evaluated within organizations in Austria and Germany. However, as mobile devices became an integral part of society and more powerful devices appeared, the goal of pushing microlearning to mobile phones was clear: integrating the benefits of micro-content (small learning steps, easy learning) with the advantages of mobile-learning (anytime and anyplace or mobility context).

Stage 3: MicroLearning on Mobile Platform

The introduction of smartphones has given rise to next generation of mobile applications that can leverage new forms of learning on mobile devices. The third version of our KnowledgePulse is now available on mobile platforms, such as Apple's IOS, Android and Blackberry - as shown in Figure 4.

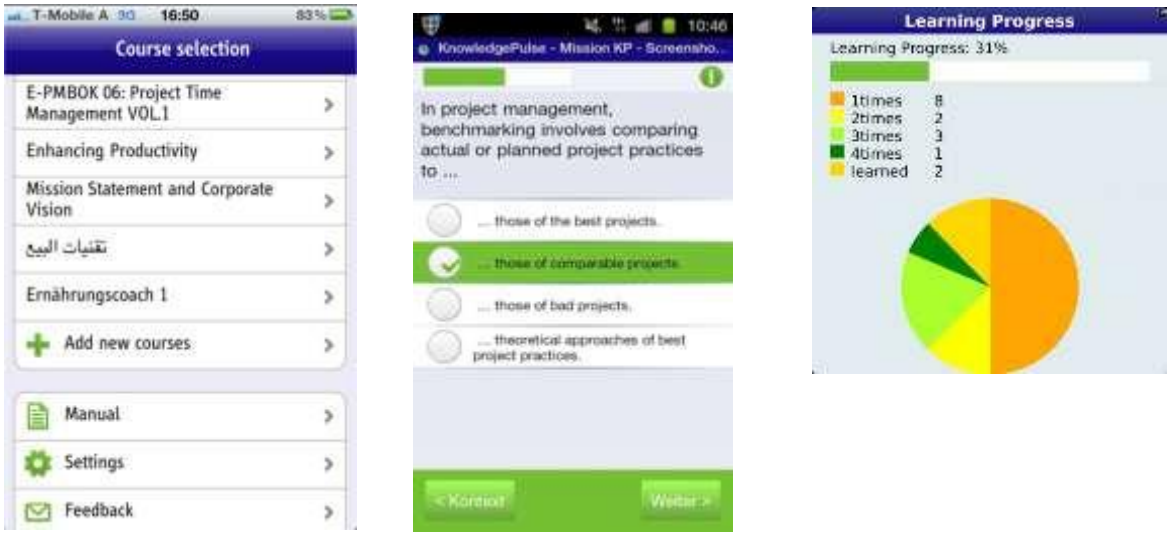

Figure 4: The course selection menu on the KnowledgePulse for iPhone, a learning card on the KnowledgePulse for Android, and the visualization of the learning progress on the KnowledgePulse for BlackBerry

RSA FG is currently involved in two European research projects that focus on mobile learning, collaboration and context-awareness. In the latter project, we have started exploring the possibilities of location-aware context data which creates new learning experiences (e.g. through connectedness to different information repositories such as calendar, task managers), activity monitoring, as well as sensors within the mobile device (speed, light, audio, etc.). Our preliminary research results with usage of the KnowledgePulse for Windows and the KnowledgePulse for mobiles are promising (see

next section) and with our new designs we aim at further increasing possibilities for micro-learning.

5 Case Studies of Product in Working Environments

There is evidence in the research literature for usability testing methodologies for the m-learning environments, in terms of the ease-of-use and efficiency of the user interface of the environment. Most usability testing includes questionnaire surveys or interviews (in the place, telephone or email), or observational studies; or quantitative measuring of some usability attributes as: learnability, efficiency, simplicity, memorability, readability, learning performance, errors, and satisfaction (Seong & Broga, 2006).

Moreover, many of the studies are merely studies of prototypes and using student populations (Zhang & Ren, 2011; Zhao, et.al., 2010; Kovachev, et.al., 2011) . The studies evaluating the presented micro-learning system differ significantly as the 90% are real world studies of a market-ready product used in professional or corporate working environments by employees. Nonetheless, these studies are to be considered propaedeutic and the authors intend to collaborate on developing a framework (Motiwalla, 2007) which has the potential to serve as a standard for comparative research into learning efficiency, effectiveness and user satisfaction.

Following an approach of rapid prototyping into the market, the KP application was deployed in the field to evaluate our system with our client companies, to gather usability data through learning performance, errors and user satisfaction. These case scenarios of deployment differed widely from one another (usage scenario, type of company, type of content). The gathered feedback was used in our re-design and rapid development process. In the following sections, we will present a case study for each stage outlined earlier to illustrate the usability feedback from the users. All three case studies reported here were conducted in the field: two with organizations using the system in a real setting, and one with students in a University course. The following subsections present more details on the the studies and user feedback.

System evaluated	*Use case*	*Number of participants*	*Percentage of participants regularly using the system.*
Lernschoner on a PC Screensaver	University course	30	73%
KnowledgePulse on the Windows platform	Governmental training	62	82%
KnowledgePulse on mobile and Windows platforms	Governmental training	33	48%

Table 1: Overview of the three case studies presented within the paper

Feedback from all use cases is being used currently to develop a mobile-micro learning system framework that will use to evaluate the KnowledgePulse and micro-learning systems, in general. RSA FG is planning to deploy a large scale roll-out of the KP mobile application, later this year in two different institutions that will involve a large number of users. This will allow us to conduct an in-depth study with our system using a formal survey based on our framework of usability and user acceptance.

Case 1: Lernschoner on a PC ScreenSaver

The first generation of a micro-learning system was implemented as an application prototype by integrating it with a PC screensaver. The prototype was named Lernschoner, a term referring to the German term for screen-saver.

The key idea of the application was to integrate learning into the desk-top environment at workplaces of offices workers. The concept stipulated that workers switch activities and also take short breaks in working on their PCs. When returning to the computer, they should find a learning invitation instead of or similar to a screensaver, thus offering up the opportunity to learn. This way the concept of integrated micro-learning was realised. The first prototypes were implemented in PHP as a general-purpose server-side scripting language and relational database on the server and the client-side graphical user interface on PC with MS Windows as operating system.

A limited case study was conducted following this implementation with 30 users in 2007. The use case was set at the University of Innsbruck within a class of philosophy for science. The course used consisted of 74 learning cards. The main research questions regarded usability of the system and the didactical questions (number of cards presented).

The data gathered by a survey showed that a high percentage of users started using the system with only limited instruction and that the concept was simple enough to make learning easy. Approximately, 22 users (75%) started using the system within the first two weeks and frequency increased with time. Because this was limited feature system prototype, the original assumption was that a much lower percentage of learners would use the system.

Further, the frequency of use of this first generation of micro-learning system also exceeded expectations. Users undertook an average of 15 learning steps per day. Assuming 200 workdays per year, KP prototype would be used for 3,000 learning steps per user in a year.

In sum, this first study showed that the concept of micro-learning was accepted by users. The case study user group emerged as highly motivated to use the learning materials offered by the system and they did so voluntarily. This case demonstrated the acceptance of micro-learning and the fact that users were learning voluntarily with such a system.

Case 2: Knowledge-Pulse on Windows PC

The full development of the KnowledgePulse micro-learning for Windows system gave us the opportunity to quickly move into the field and deploy the system in companies and organisations for real usage.

Currently, about 50 organizations are using the system. In the following section, we will present the results of our first case study done with a governmental entity of the Republic of Austria. Goal of the KnowledgePulse implementation was to drive training of public servants and thus help to improve the quality of governmental services provided to the public.

The study was conducted in October-November 2010 and involved 62 users who had two courses with the KP system. The main focus was on (1) the actual usage of the KP for Windows and on (2) the perceived usability, ease of use and support in the learning

endeavours. Two courses were created for the use with the KnowledgePulse system. To investigate actual usage of the system, the log data from the KP-Server were analysed. Perceived ease of use, usability and learning support were evaluated using an online questionnaire.

The server logs were analysed for the whole period of usage. The results showed a high usage, with 51 participants of 62 using the system regularly. Within 1 month ¾ of participants had finished the course. At the end of the term, 91% of the participants that used the system had completed the micro-learning course. In average every user completed 143 learning steps within the learning period. Participants did an average of 10-20 learning steps per day.

A user survey was conducted six weeks after the end of the course and was answered by a third of participants. The responses showed that the learners experienced the system as easy to use – without any need for instructions or training on how to use the system. The small learning steps supported by the system were perceived as fun to learn and motivating. We did not measure the effectiveness of the learning, but in the questions on perceived effectiveness 70% say that the KP for Windows supports the learning of factual knowledge well. 60% stated that learning with KP helped to increase the knowledge on the topic of the two courses. And 35% thought that will remember the content in a long term. Significant was also the fact that learners experienced learning with the KP to be a form of TEL which is well integrated into the working day.

This implementation had a long lead time in terms of planning and execution. In addition to an intense phase of preparation, we assumed that the corporate culture of the public administration in the ministry positively influenced the uptake of the learning. In summary, this study was too narrow to allow general statements and definite conclusions on the advantages of the system, but the evidence of the reported study showed that the KP system is perceived well and has great potential as an application product is successfully engaging users.

Case 3: Knowledge-Pulse on Mobile Platforms

In this case study we used both, KnowledgePulse for Windows and the KnowledgePulse mobile (iPhone). The study was conducted in June and July of 2011. 33 employees from different government departments of an Arab Gulf Emirate took part. Two courses with a total number of 71 learning cards were created. Participants were free to choose to use KP for Windows and/or KP for iPhone, with support for the installation of the clients was provided.

As in use case 2, we evaluated the usage of the 33 participants with two independent data sources. The first source we used was the application usage statistics from the KP Server, which logs the complete learning progress of the participants, including number of learning cards accessed, percentage of courses completed, number of times accessed, and other user activity. The usage statistics indicated that about half the participants used the KnowledgePulse system.

The second data source for this study was an online survey conducted after the learning period of one month. 50% of the participants answered the questionnaire. Participants reflected on their micro-earning experience with KP application and the learning content (see Figure 5). KP is considered essential for learning: 86% of respondents say

that they would not have repeated the learning content without the KnowledgePulse. The survey also showed that the learning activity depended on the relevance of the learning content for the target users. Furthermore, we found that usage of both Windows and iPhone increases the learning activity significantly: Those users who used KnowledgePulse on their PC and on their iPhone achieved the highest learning frequency (with more than six learning sessions per a day).

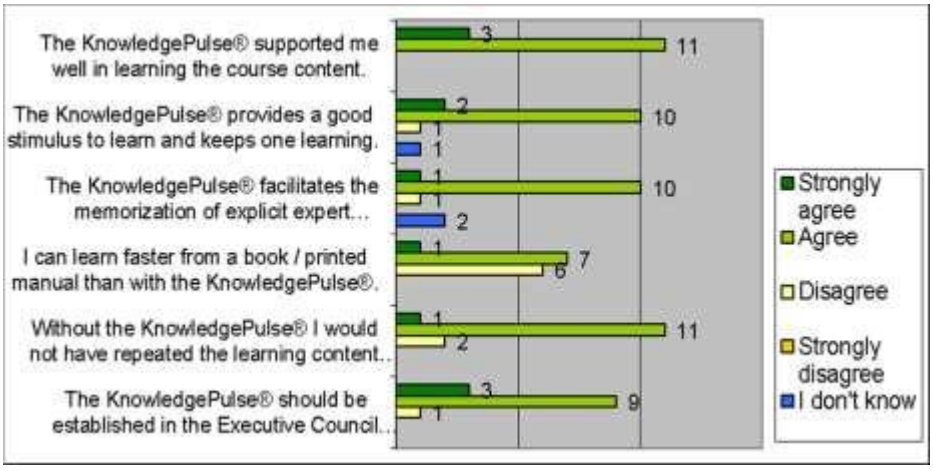

Figure 5: A bar chart showing responses of participants regarding some aspects of acceptance.

The user satisfaction with the KP was excellent: All respondents stated that the KnowledgePulse was easy to use and on learning effectiveness (see Figure 5). 100% of the respondents stated that the KP application helped them in the learning process. 90% of the written comments on the user learning experiences with KP were positive: for example, some qualitative comments from users were "Learning with KP was a good experience to me", "KP gave me more experience in principles of excellence and costumer centric excellence", "Learning with KP was a good experience to me". Only one participant stated that he/she lost the interest after some time: "it's normal and by the time I lost the interest of learning using Knowledge Pulse."

This anecdotal evidence provides the foundation to move forward with a larger study with the users of the KP system in future. Compared to other e-learning systems, KP seems to cause a completely different effect. The usage rate was high. This contrasts with other reported m-learning studies (Vinu, et. al., 2011; Motiwalla, 2007) that had exhibited frustration from the initial users who are not able to increase the productivity with new mobile systems easily.

6 Future Research and Evaluation Framework

In this paper, we have introduced micro-learning on mobiles and argued how it leverages the ubiquity, intimacy and usability of mobile devices with their small sized screens and miniature keyboards for a new form of learning. With the strongly increasing share of smart phones and mobile broadband connectivity mobile e-learning environments have a significant potential of reaching more learners globally. The micro-learning solution of the KnowledgePulse is a model implementation focussing the one learning objective of memorisation of explicit content or root knowledge.

KP has been designed to initiate micro-interactions to overcome information overload experienced by users in today's digital working environment and to make repetition

learning convenient in small little steps. The paper has provided an overview of KnowledgePulse usage in three cases that involved about hundred users who have used the system in real working settings. The case studies are suggestive and warrant a more developed evaluation with larger groups of users.

Our future research goals are to understand the impact of micro and mobile learning with other criteria such personalization, context or location awareness, micro-content and micro-interactions on learner effectiveness. We would like to study how the learning improves with smaller steps with micro-content, self-paced, and high interaction environment and what types of learning are conducive to micro-learning. In near term, we plan to expand our current design and evaluation of KP with the micro-mobile learning framework presented in table 2.

Mobile-Micro Learning	Conversational Pedagogy	Collaborative Pedagogy	Examples
PUSH Technology	Learning Aids & Mentoring Agents	Communication Aids	Digital Flash Cards, Push Buttons, Alerts, (ex: KnowledgePulse™)
PULL Technology	System Tools & Resources	Simulated Classrooms	e-learning Apps, Social Networks & IMs (ex: MicroStep™)
	Alerts, Flash Cards, micro-Blogs, micro-Wikis, micro-assessments	Social Nets, Tweets, SMS, MMS	**M-M Learning**

Table 2: Micro-Mobile Learning Framework

This framework will attempt to understand which learning pedagogies apply to micro-learning for improving the learning effectiveness and also what types of learning is conducive to micro-learning. This framework will try to integrate the concepts from mobile connectivity and micro-learning into generation next generation micro-mobile learning applications. For example, the mobile connectivity research suggests the content delivery is more effective when a combination of push and pull mechanisms are used (Zhang, 2003).

Similarly, the content delivered is more useful when it is personalized (i.e., when students can control or filter the content), collaborative (i.e., when students can reflect and react to the information that they receive), as suggested by the constructive-collaborative (Brown & Campione, 1996) and the conversation (Pask, 1975) learning models, and delivered in micro-chunks or as needed by the user either to solve a problem or make a decision as suggested by human information processing capability (Cowan, 2001). This analysis will hopefully provide us some guidelines on where micro-learning is effective and where it is not.

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