International Journal of Mobile Learning and Organisation archive
07olume 1 Issue 2, March 2007
Pages 122-139

Mobile learning – challenges and potentials

Michaela Denk*

EC3 – E-Commerce Competence Center,
Donau City Str. 1, A-1220 Wien
E-mail: michaela.denk@ec3.at
*Corresponding author

Abstract: The transition to an information society and the therewith strongly related need of lifelong and life-wide learning on the one hand, and the increasing coverage of and developments in mobile information and communication technology on the other hand establish the foundation of mobile learning. This paper discusses the challenges and potentials of the present mobile learning trend from a broad perspective. Going back to the primal origins of learning, it reviews mobile learning as well as related concepts and definitions and investigates requirements, potential barriers and benefits of mobile learning. Eventually, promising mobile learning applications are examined and a future empirical study is outlined.

Keywords: definitions; e-learning; mobile education; mobile learning; m-learning applications; m-learning initiatives; problems and challenges of m-learning; ubiquitous learning.

Reference to this paper should be made as follows: Denk, M., Weber, M. and Belfin, R. (2007) 'Mobile learning – challenges and potentials', *Int. J. Mobile Learning and Organisation*, Vol. 1, No. 2, pp.122–139.

Biographical notes: Michaela Denk studied statistics at the University of Vienna with main focus on statistical meta-information systems and data integration. Since 2002, she has been Senior Researcher in the Digital Business Research and Development group of the Electronic Commerce Competence Center (EC3) where she is currently working on the measurement of competence resources, requirements and development as input for optimal project portfolio selection. She is also an external lecturer at the University of Vienna.

Mobile learning – challenges and potentials

Michael Weber studied Economics and Commerce at the Vienna University of Economics and Business Administration. He specialised in business informatics and strategic management and currently works at the Electronic Commerce Competence Center (EC3) in Vienna, focussing on issues of digital business in a Networked Economy.

Roland Belfin studied Business Management with a special focus on controlling and information management in Vienna. For more than 8 years, he has been working at the Austrian Broadcasting and Telecommunications Regulatory Authority (RTR). From the very beginning of telecommunications liberalisation in Austria, he has been involved in solving the main regulatory issues such as fair access to infrastructure, fair allocation of frequencies and market analysis. Currently, he is involved in setting up a strategic 5 years ICT plan for Austria.

1 Introduction

The history of learning and consequently knowing has fundamentally been influenced by the evolution of reading and writing as cultural skills in combination with the development of the script and the alphabet – a process that spans several millennia BC. Papyrus, parchment and, eventually, paper accompanied this process and enabled the collection, sharing and distribution of information embodied in these path-breaking ways of representation and data storage. However, the transfer of information accelerated only slowly which was – apart from societal and organisational issues (e.g. concerning the education of the public) – due to lacking capabilities for cost-efficient production and distribution of (written) information. The replacement of papyrus with parchment and again of parchment with paper were important steps in this respect but it took a long time until a major breakthrough concerning the dissemination of information was achieved, i.e. the invention of an efficient way of printing books by Gutenberg at around 1440 AC. The diffusion of this innovation was rather quick, which indicates that the society at that time was ready (and more or less owned the appropriate skills) for this development, the '*printed book*', a new media that provided the individual with the possibility to access information anywhere and anytime without critical dependencies and that could be produced quickly and relatively cost-efficiently which increased the potential to reach the mass. As a consequence the (printed) book can be seen as the first means of mobile learning for a mass market, i.e. learning that affects the collective memory or the 'shared knowledge' of a society. (A definition of learning is provided in Section 2.)

The advances in Information and Communication Technologies (ICT) during the past decades (and more generally since the age of Enlightenment; Flichy, 1994) have enhanced the possibilities of coordination, interaction and collaboration in a society, not only from an economic point of view. The progressive individualisation of communication and the ongoing enrichment of mobile devices with data and information processing capabilities accompany this development and apparently lead to a convergence of different ICT developments (e.g. the internet as communication infrastructure; technologies processing and transferring audio/video signals or data in general) as featured in 'ubiquitous computing' (or similar 'pervasive computing') scenarios (Weiser, 1991; Burkhardt et al., 2001). The combination of the advantages of

ICT with the advantages of mobile devices facilitates an improved access to data and information; and therefore, it provides new ways for individuals to enhance and facilitate their learning efforts. Consequently, the acquisition of – from an individual perspective – 'relevant' knowledge becomes feasible for a much wider audience at an increasingly personal level, provided that the necessary skills and the technical equipment are available. In essence, this is true for industrialised countries. The term 'relevant knowledge' in this context refers to Hayek, who examined coordination issues in an economy and emphasised the role of knowledge and its distribution for wealth generation in a society (Hayek, 1937, 1945). Thereby, 'relevant knowledge' connotes the knowledge that is necessary for individuals to make and realise plans to fulfil their specific needs in exchange with others who have plans themselves. However, this knowledge cannot be defined in advance in its entirety, which forms the basis for the explanation of dynamics and the role of coordination both in markets and in the society in general. Moreover, this fact underlines the meaning of the distribution of information and the subsequent generation of knowledge that can fundamentally be improved by means of ICT and appropriate learning strategies to support the allocation of knowledge on a large scale (Weber and Froeschl, 2006). This can in turn facilitate cooperation. Therefore, a timeless but nowadays increasingly important challenge for a society and its economy is to expand the individual's information base and, consequently, widen the limits of individual knowledge. Learning techniques that make use of mobile devices in combination with traditional as well as web-based ways of learning appear to have a vast potential to outperform established approaches.

The variety of governmental e-learning initiatives is an indicator of the high relevance of up-to-date multi-media support of public education as well as digital literacy in today's educational policy. For instance several national programmes (such as PLS, 2004) have started to implement the e-learning initiative of the European Union (European Union, 2003). Within the last 5 years, a sharp increase in the number and the variety of pilots and trials involving m-learning has been observed (Kukulska-Hulme and Traxler, 2005), as reflected in and supported by submissions to the MLEARN conference series (MLEARN 2002 consortium, 2002; Attewell and Savill-Smith, 2004a,c; MLEARN 2005 consortium, 2005) or to the WMTE workshop series (IEEE International Workshop on Mobile and Wireless Technologies in Education, for instance Sharples et al., 2005) that were both initiated in 2002, and by the emergence of smaller and local conferences.

This paper examines existing definitions of mobile learning and related concepts to establish a contextual framework for the intended discussion of challenges and potentials of mobile learning. Requirements, potential barriers and benefits of mobile learning are discussed. Eventually, promising mobile learning applications are identified and an outlook on future research is presented.

2 What is mobile learning?

Regarding (printed) books as first means of mobile learning raises the question whether m-learning is just a catchy terminology to promote fancy mobile devices that enable people to gather information and, thus, create new knowledge 'on the move' – which is, in fact, nothing new. Laouris and Eteoklous (2005) even go one step further, viewing the human brain, which continuously collects, stores and processes information as the major learning instrument, and consequently state that learning has always been mobile. This

quite radical perspective might not be meant entirely seriously; still, it properly stresses the question for the background, motivation, or even justification of the recent m-learning trend.

A first investigation of this 'new' concept applying a Google search yielded the following figures (figures of January and June 2005 taken from Laouris and Eteoklous, 2005):

- Approximately 1,200 matches were retrieved for [+'mobile learning' +definition] in January 2005, circa 22,700 in June 2005, and about the same number of matches in November 2005.
- Using the same search phrase on scholar.google.com resulted in 231 items at the beginning of 2005 and in 313 items in November 2005.
- The number of hits for [+'mobile learning' +definition] rose from 45,100 in January 2005 to 135,000 in November of the same year.

Apparently, there are a huge number of different and partly even contradictory definitions. The vast majority simply emphasises the 'anywhere, anytime' aspect or focuses on the technology, in particular on the usage of mobile devices. These 'technocratic' definitions typically consider mobile learning as direct descendant of e-learning in the evolution of computer-assisted learning or as subset of e-learning (such as Brown, 2004, or the entry for 'e-learning' in the free internet encyclopaedia Wikipedia, 2005). For instance, Milrad (2003) plainly defines m-learning as 'e-learning using mobile devices and wireless transmission' where e-learning denotes 'learning supported by digital 'electronic' tools and media', or Kossen (2001) delineates m-learning as 'fusion of mobile technology and e-learning … making learning available anywhere, anytime'. Comparable definitions are provided by Quinn (2000), Freysen (2004) or Trifonova and Ronchetti (2004), and the list could be extended arbitrarily. Focusing on the technological aspect of 'modern' mobile learning, this evolutionary view seems to make sense; however, in addition, two types of e-learning (and m-learning) have to be discerned, videlicet network-learning (n-learning, or online learning; Polsani, 2003), which is often – inadequately – equated with e-learning (for example Wikipedia, 2005, Kossen, 2001), and offline learning, as, for instance, courses on CD-ROMs. N-learning is sometimes regarded as descendant of e-learning from which wireless learning (w-learning, see for instance the website of the Manolo project, 2005) has evolved; then, m-learning is a further development of w-learning by exchanging (portable) PCs by mobile devices. Though laptops might also be deemed mobile devices (which is rather common in the US), usually only devices of certain compactness are included in the definition of mobile devices (Keegan, 2002, 2005).

Nonetheless, technological progress is a continuing process and future m-ICT devices cannot be forecasted seriously, which underlines the need for a device-independent definition of mobile learning, as already highlighted by Pinkwart, Hoppe, Milrad, and Perez (2003). A reasonable and practicable definition of mobile learning should not solely concentrate on the learning devices, but (at least) include the advantages of mobility (Keegan, 2002) and the concept of learning as well (Laouris and Eteoklous, 2005), in particular by shifting the focus to the learner and his/her environment (Pinkwart et al., 2003). From this perspective, definitions such as the one often cited by Chabra and Figueiredo (2002) – 'the ability to receive learning anytime, anywhere and on any device' – appear somewhat fragmentary, despite their device-independence. Enhancing

learner-centricity especially implies accounting for the aspects of individuality and personalisation, communication, coordination and collaboration in the concept of mobile learning; according to Lockitt (2005), this way of thinking will contribute to a shift to a new learning paradigm.

In order to come to a definition of mobile learning, besides the inherent aspect of mobility, the concept of learning has to be clarified. Ensuing a constructivist approach, learning is regarded as the dynamic process of coming to know in which learners construct transiently stable interpretations of their world – 'new knowledge' – in cooperation with peers and teachers in some learning activity, such as discussions, solving problems (in teams or individually) or experiments (see for instance Milrad, 2003; Sharples, 2005). In general, main emphasis is laid on construction, cooperation and communication. Analogously, reverting to educational literature and quite in line with an earlier definition of Jonassen, Peck and Wilson (1999), Sharples (2002) identifies the three C's of effective learning:

1 the construction of understanding by relating new experience to existing knowledge

2 the conversation with teachers, peers, and oneself to interpret the results and

3 the control of the learning process, i.e. the active pursuing of information rather than its passive consumption.

Actually, the second C subsumes the aspects of cooperation and communication. Nyíri (2002, 2003) and Sharples (2005) particularly stress the communicational aspect by delineating learning as conversation in context where learners engage in dialogues. In compliance with these definitions, Nyíri (2002) states that mobile learning is the 'learning that arises in the course of person-to-person mobile communication'. Townsend (2000) as well as Laouris and Eteoklous (2005) even see the mobile phone as extension of the body, the third hear-and-talk organ that demolishes distance and will soon be adopted (if it is not already) as natural interface for shopping, bank transactions, booking of tickets, communication between people, radio and television as well as up-to-date information (see also Nyíri, 2002).

Claiming that learning is an active process of jointly building knowledge and skills in interaction and through practice within a supportive community, Milrad (2003) and Sharples, Taylor and Vavoula (2005) put more emphasis on the social aspect and highlight the necessity of a learning community in which cooperation and collaboration are a matter of course. Obviously, cooperation and collaboration, both, require coordination of (learning) community members and, hence, communication between them as well. Especially Milrad (2003) also stresses the active role of learners in the process of discovery and knowledge creation (the third of Sharples' three C's), demanding a high degree of self-motivation, discipline and self-initiative, and on the contrary, implying high autonomy, self-determination, and thus, individuality and freedom in the learning process, which are among the main challenges (Abfalter, Mirski and Hitz, 2004) and benefits (Kuszpa, 2004; 2005a,b) of mobile learning.

Sharples' definition of learning as conversation in context (Sharples, 2005) reveals another vital element of the learning process: the context. On the one hand, new information has to be put in context, i.e. it has to be related to something already known (existing knowledge), to enable the construction of new knowledge. On the other hand, the relevance of information is subject to the context of the learner, i.e. his/her situation, encompassing, amongst others, location and time, the learner's personal preferences, the

characteristics of the learning team as well as the technical situation, such as device features, in case of ICT-supported learning (Ferscha, 2002). Ferscha, Holzmann and Oppl (2004) stress the particular importance of team context, since learners form teams to gain knowledge by discourse and dialogue, which leads back to the second of the three C's – conversation – that actually subsumes four C's of its own, namely communication, coordination, cooperation and collaboration.

A rather broad, but complex definition including many of the required components has been developed by Laouris and Eteokleous (2005). They define mobile learning as a function of several interacting parameters that could be summarised as context, content, and communication. In spite of its comparatively high complexity due to the nesting of function parameters, this definition is still incomplete in terms of the three C's and their extensions, as discussed in the previous paragraphs. The following is an attempt to give a comprehensive definition of mobile learning that rests on 11 columns (11 C's), encompassing the learning component, the mobility component and the technology component as well:

- *Learning* (7 C's): the dynamic process of coming to know in which learners *construct* new knowledge in active *collaboration* with peers and teachers; construction includes putting new (relevant) information in *context*; collaboration requires *communication*, *coordination* and *cooperation*; active implies that the learners autonomously *control* the learning process.
- *Mobility* (3 C's): the flexibility of learning anywhere (unconfined – *complete* – space), anytime (*continuous* time) and aware of *context* (i.e. in consideration of the present situation of the learner, which means that relevant information is available, where relevance highly depends on the actual situation, including e.g. at the right place and the right time).
- *Technology* (1 C): the usage of up-to-date (*contemporary*) resources, devices, and tools for the retrieval, storage, processing, and sharing of information, i.e. to enable as many as possible of the other ten C's, where books were up-to-date in times of Gutenberg, and mobile phones, smartphones or personal digital assistants (PDAs) may be up-to-date nowadays.

3 Requirements and opportunities

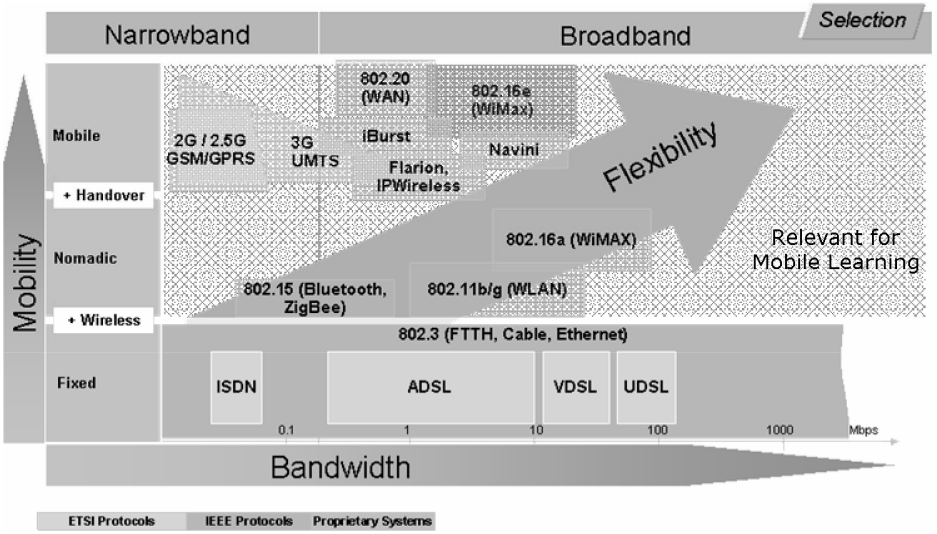
Technological and educational issues are crucial prerequisites and potential barriers of m-learning. The former encompass bandwidth and access infrastructure requirements of modern mobile applications, standards of m-ICT, characteristics of m-learning devices, as well as the knowledge and skills that learners need to use mobile learning. The latter include questions of suitable content and its appropriate representation, the negative effect of the fragmentation of learning times, and problems related to the usage of mobile devices in class. Financial and business-related aspects also have to be kept in mind.

3.1 Prerequisites

Bandwidth requirements of mobile learning heavily depend on the types of communication and collaboration of the concrete learning application, ranging from

simple SMS (Short Message Service) based quizzes to video-conferencing tools with differing needs concerning the degree of interactivity. For example, Canadian experts (PlannedApproach.com, 2000) specify the needs with about 110–7 $Mbits^{-1}$. Regarding access infrastructures, many different technologies are already available, which can be characterised with respect to the level of mobility and the available bandwidth. Current technological development yields an increasing extent of the combination of a higher degree of mobility as well as higher bandwidth, resulting in more flexibility and a greater variety of possibilities for mobile learning, as illustrated in Figure 1 (*adapted from* Taga, 2005).

Figure 1 Access technologies



Strong growth rates can be observed across the world regarding the adoption of mobile devices. For example, the mobile phone penetration rate has reached more than 92% across the EU in 2005 (European Commission, 2006). Mobile devices are increasingly being equipped with more advanced features, such as streaming video or colour-touch screens, leveraging the possibilities of mobile learning. Still, currently, mobile devices are not as highly developed as would be necessary for mobile learning. Problems are the limited screen size, which might be overcome by flexible screens or small projectors, or the limitation of input interfaces. The frequent incompatibility of mobile devices with laptops, problems with the software during installation or updating, the limited memory capacity, and the short battery life are also among the current barriers of mobile learning (Kuszpa, 2005b). Standardisation is of high relevance in this context (Denk and Hackl, 2003; Carlsson et al., 2005).

As for traditional e-learning, a minimum degree of user knowledge, in particular a certain level of ICT affinity, is necessary for m-learning. Unified user interfaces and easy to handle applications (and thus again: standards) can foster the take off of mobile learning. A recent survey on m-learning acceptance indicates that, at present, especially simple SMS-based learning systems have a high potential to succeed, primarily because

of the users' high familiarity with this means of communication as well as the rather low cost (Tretiakov and Kinshuk, 2005).

One key requirement is the availability and appropriate representation of mobile learning content, as already indicated in the expert surveys mentioned above. Mobile learning does not simply amount to transferring e-learning to mobile devices; the development of specific learning material is necessary instead of reusing e-learning material designed for PCs or laptops. Stone and Livingstone (2004) discuss the shortcomings of simply converting learning content destined for a particular technological environment (e.g. e-learning) to fit into another environment (e.g. m-learning). They suggest adaptive content architectures to design and deliver m-learning material that is suitable and effective from a pedagogical perspective as well as scalable and portable to multiple technologies.

Moreover, various user groups are to be served. On the one hand, the needs of learners and teachers have to be accounted for. On the other hand, varying requirements apply to different groups using distinct types or applications of learning. For instance, the following user groups and learning types can be discerned: pupils and students in curricular-based learning, tourists or workers in particular types of problem-led learning, commuters in occasional learning, or school dropouts and young unemployed in mobile learning programmes aiming at the improvement of social inclusion. The most important aspect in the context of content development is the consideration of human needs and hence the avoidance of mere technology driven approaches.

3.2 Barriers

One of the main challenges concerning mobile learning is the fragmentation of learning time (Pehkonen, Syvänen and Turunen, 2004). Partly due to the increasing number of information sources, partly resulting from the combination of work, study and leisure (i.e. the amalgamation of learning with everyday life), the learning process is divided into various phases. This separation obstructs a meaningful 'continuum' of learning that would be required to enable reasonable accumulation of acquired knowledge. Especially in occasional learning, fragmentation is also caused by environmental disturbances and technical problems (e.g. bad network connections, problems with the device or application), leading to less concentration.

In addition, the expert surveys mentioned above, identified financial aspects such as high operating and initial costs or limited financial resources as important potential barriers for the adoption of m-business by companies and customers (Denk and Hackl, 2003). In fact, the cost of connectivity is often high, whereas the cost of equipment depends on the type of device required for a particular m-learning application. Moreover, the importance of cost effectiveness for successful mobile learning applications, as stressed by Abfalter et al. (2004), has to be accounted for. If m-learning is privately used, who will have to bear the costs of learning applications? If learners are willing to pay, how much are they willing to pay? So far, only few surveys investigating this topic can be found. Constantiou, Damsgaard and Knutsen (2004) revealed that services must be relevant in specific situations (as for instance location based information at a high level of granularity for 'tourist learning') and offer high added-value to achieve a reasonable willingness to pay. In a survey among tourists and residents in a tourist region, about 30% stated their willingness to pay for an 'adequate' m-learning offer, where only a quarter declared that the price for a learning offer must not exceed the price for

a domestic mobile call (Abfalter et al., 2004). In particular, flat fees for a bundle of favourite services seem to be accepted by potential learners. Apart from the rare availability of studies of the willingness to pay, a general lack of business models for mobile business (and thus also m-learning) application providers can be identified (Denk and Hackl, 2003).

Considering problems related to (curricular) m-learning in schools or at universities, the disturbance of lessons and lectures by means of (inadequate) usage of mobile devices emerges, posing a challenge to the traditional system of education. Mifsud (2004) talks about 'disruptive technology' in this context. Moreover, the usage of devices owned by the educational institution is a matter of trust; damages and theft may occur, as well as the abuse of the devices for personal calls, the calling of premium rate numbers, or cheating during examinations.

3.3 Benefits

Despite the undoubted hurdles and limitations of mobile learning, its benefits obviously outweigh. The two most evident advantages, the flexibility regarding time and location (anytime, anywhere), are due to the portability of modern small and lightweight devices as well as to the extensive coverage of today's mobile telecommunication networks. Apparently, they characterise articles on m-business, m-learning and so on, and are confirmed in lots of expert and customer surveys (Denk and Hackl, 2003; Carlsson et al., 2005; Kuszpa, 2005b). Apart from these two inherent mobility features mobile learning involves many advantages concerning the other C's of the definition given in section 2 as well as several other convincing characteristics.

The real-time feature of mobile applications in general allows synchronous communication and, thus, dynamic interaction in learning settings, particularly in collaborative learning situations. Examples are (peer-to-peer) discussions, just-in-time access to information resources, and instant feedback during learning (e.g. on questions emerging when doing homework) or in assessment situations. Communication is usually effected by SMS/MMS, instant messaging/chat, and – rather conventional – voice (or video) telephony (also by means of conference circuits). Social interactivity and data exchange are supported by different (synchronous as well as asynchronous) communication channels, improving the reachability of peers, teachers and learners as well as the accessibility of learning material and assessment, which facilitates coordination, cooperation, and hence, collaboration. Zurita and Nussbaum (2004) showed that a constructivist learning environment mainly focusing on the collaboration of learners (and teachers) obtains significantly different results when supported by mobile technology.

In a series of expert surveys conducted in several European countries, the up-to-dateness of mobile information, the real-time feature of mobile applications as well as the increased efficiency and effectiveness of mobile communication were among the leading motivations of customers and businesses to use mobile applications (Denk and Hackl, 2003; Denk and Wiesbauer, 2004; Carlsson et al., 2005). In addition, the resulting time saving and enhanced productivity, which are also due to the exploitation of niche times, were considered as important motivators.

Certainly, mobile learning includes asynchronous communication and learning as well, for instance through e-mail, message boards, forums, blogs and individual, self-paced retrieval and usage of learning material. (For an overview of synchronous and

asynchronous types of collaboration see O'Nuallain and Brennan, 2004). A recent expert survey on trends of mobile learning (Kuszpa, 2005a,b) revealed that the increased individuality and autonomy of the learning process, for example concerning learning time budget and speed, can be regarded as one major asset of m-learning. Learners are enabled to actively control their learning process which, on the one hand, has a positive impact on the motivation of learners (Milrad, 2003), yet on the other hand requires a high degree of discipline and self-initiative, making mobile learning especially suitable for higher education and (voluntary) adult learning (Abfalter et al., 2004). Besides, the self-directedness also allows the self-recognition of existing abilities as well as the self-identification of weaknesses, i.e. areas where assistance is required. While the role of teachers transforms into the function of a mentor or guide, learners adopt a highly active role that can raise self-confidence, in particular of teen learners.

The learner-centricity is further fostered by means of personalisation and customisation of mobile devices as well as learning applications. Learning modules can be selected based on individual preferences, prior knowledge and the concrete learning progress or via collaborative filtering, reflecting the activities and 'learning histories' of other learners, and even user interfaces can be adapted to personal needs, facilitating a high degree of individual support (Milrad, 2003; Andronico et al., 2004). From this point of view, m-learning fits well into Falk and Dierking's concept of free-choice learning (2002), defined as self-directed, voluntary, guided by individual needs and interests, and mainly informal learning (i.e. taking place outside formal educational structures such as schools, universities, or courses; Pehkonen et al., 2004), that builds the foundation for lifelong learning. Mifsud (2003) attributes the potential of bridging the gap between formal learning inside classrooms and informal learning outside to mobile learning. In fact, the reduced formality and the increased fun factor of unconventional 'mobile lessons' at school, the possibility of 'learning by playing' and the high degree of collaboration positively affect the motivation of learners (this holds especially for children and teenagers), lead to improvements concerning the quality and quantity of student work and may even engage reluctant learners (Swan, van't Hooft and Kratcoski, 2005). If not successful in stimulating knowledge construction in a particular subject, mobile learning can at least contribute to the adoption of contemporary (m-)ICT with respect to the ability to use sophisticated technology and, thus, bridge the gap between mobile phone literacy and ICT literacy. Even people with poor literacy and, hence, ICT skills make effective use of text messaging and are in regular communication with peers (Attewell, 2005; Lockitt, 2005). Personalisation also induces a high extent of inclusiveness; the integration of learners with special educational needs, for example those at the risk of dropping out of school, or, even worse, those who have already dropped out, unemployed people, and people with disabilities, into education is facilitated (Attewell, 2005). Even people not able to attend a learning session are enabled to take part.

The context-awareness of learning devices and applications is closely related to personalisation and individualisation. Context denotes the learner's situation or frame of reference. According to Dey (2000), context is any information that can be used to characterise the situation of an entity. Entity can be a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves. Consolidating different existing definitions, (at least) the following components constitute the (mobile) learning context (Dey, 2000; Falk and Dierking, 2002; Ferscha, 2002; Kadyte, 2004):

1 time and location

2 the learning space

3 the learning community

4 the technical situation, encompassing characteristics of the learning device (such as screen size and colour depth, or input and output mechanisms) and of the learning application

5 the cultural background and

6 the characteristics of the learner him-/herself.

Ferscha et al. (2004) highlight the particular importance of team context for effective learning that requires building team knowledge by means of communication. Team context includes information on personal characteristics and preferences of team members, their current activities, availability, and status in the learning process. The cultural context primarily depends on the origin of the learner and his/her current environment. For example, a mobile business expert survey indicated differences with respect to the main opportunities of mobile learning in Europe and Asia, suggesting higher potential in the Asian culture (Kadyte, 2004; Denk and Wiesbauer, 2004).

Mobile learning enables context-awareness to a high degree. The context component most often dealt with is location. Location-based services have often been named as potential 'killer applications' (Denk and Hackl, 2003; Carlsson et al., 2005) and, in fact, play a key role in mobile learning. These services encompass for instance mobile city guides (providing information on sights, attractions, restaurants, supermarkets), museum guides (supplying information on viewed artefacts, such as the Tate Modern Multimedia Tour pilots 2002–2003, see Proctor and Burton, 2004), navigation systems (e.g. active maps changing on user movement), or location services (as for example mate finders, which are very helpful in collaborative settings). The actual impact of location-awareness on socio-cognitive processes involved in collaboration was addressed in a recent empirical study on mobile collaboration by Nova, Girardin and Dillenbourg (2005). They could not verify an influence of location-awareness on task performance or on the processed cognitive workload, but identified differences concerning the extent and detailedness of communication. In another field trial, Constantiou et al. (2004) surveyed that participants mainly used location-based services when travelling or commuting, which belong to the most frequently occurring niche times ready to be exploited for (mobile) learning. Aside from these 'tourist/traveller' learning situations, location-based learning facilitates on-site experiments and field work (for example biological investigations in botanical gardens) and can provide operating instructions (e.g. for household appliances, cars or any machines/devices somebody is working on), i.e. mobile learning contributes to solving authentic problems in authentic contexts. This is usually referred to as problem-based or problem-led learning (Baber et al., 2004), or, in particular at school, as project-based learning, where pupils/students have to solve real-life problems in multi-week, multi-media, multi-subject, collaborative learning projects (Norris and Soloway, 2004).

4 Potentials and promising applications

In recent years, Lifelong and Life-wide Learning (LLL) has emerged as a complement to institutional education; in today's globalised, information or even knowledge society people need and desire to constantly enhance their knowledge and skills for the sake of their professional and/or personal development. Life-wide learning especially implies learning during leisure time. In addition to conversation, contemporary mobile devices are increasingly used for entertainment and spare-time activities; they are personal – one could even say: intimate – items that people carry with them most of the time, which makes them predestined to enable life-wide learning. Sharples (2000) also stresses the suitability of mobile ICT for supporting lifelong (and life-wide) learning by establishing relations between core characteristics of LLL and m-ICT (see also Sharples et al., 2005). However, the promise to work or learn regardless of time and place should not automatically be included in the definition of mobile learning or mobility in general (Pehkonen et al., 2004); rather, mobile learning should be regarded as a means of free-choice learning (Falk and Dierking, 2002).

In order to explore the suitability of mobile ICT for particular types of learning, Baber et al. (2004) define a 'learning space' model discerning three types of learning, videlicet curriculum-supported, problem-led and serendipitous learning. Synonyms frequently used for the latter (with slightly deviating meanings, though) are spontaneous learning, learning on-the-go, occasional learning, or *ad-hoc* learning (see for instance Malliou, Savvas and Sotiriou, 2004, on the MOTFAL-project developing mobile technologies for *ad-hoc* learning). Lifelong and life-wide learning involves all three types of learning and mobile learning is applicable to all of them.

With regard to occasional learning, actually two types can be distinguished, the intended learning during habitual niche times, for example when commuting or in waiting rooms, and the really spontaneous or serendipitous learning during times unexpectedly idle, for instance in case of delay of public transport. In general, only short and typically fragmented periods of time are available for occasional learning, impeding the learning of entirely new or complex content. In addition to the separateness of learning periods, fragmentation is essentially attributable to environmental disturbances and technical interruptions such as bad network connections or problems with the learning device or application, resulting in poor concentration. Hence, repeating and reviewing already learned content, checking the learning progress, and memorising, are particularly apt for occasional learning, which was confirmed by an expert survey on mobile learning (Kuszpa, 2005b), also revealing the increase of learning success due to the more frequent repetition of learning content in niche times. Checking the current learning status can be accomplished by short quizzes, e.g. with true/false statements, multiple choice questions, closes, or test dialogues. Language learning, in particular vocabulary training, is especially suitable for occasional learning. For a discussion of the appropriateness of mobile ICT for language learning see for example Kadyte (2004) and Fallahkhair, Pemberton and Griffiths (2005). Obviously, occasional learning is mainly used in support of curriculum-based (or perhaps also problem-led) learning.

Problem-led learning or learning on demand offers a broad field of applications for mobile learning, primarily to enable the retrieval of supporting information when required and on-site, including mobile travel, city or museum guides, dictionaries, active maps, operating instructions, manuals for the mobile worker, and different other context-aware applications as already discussed in the previous section. At present, applications

for tourists or travellers and job-related applications appear most promising. Besides, mobile learning devices can be used for lexical inquiries, just like a conventional encyclopaedia, or for taking memos like a simple notebook, just in time and at the face, which are both functionalities also relevant to occasional and curriculum-based learning. Recent initiatives, such as 'Semapedia', that tag real-life objects with semacode nodes in order to create links to learning resources provide an interesting and convenient opportunity for individuals to learn 'on the go' (Rondeau and Wiechers, 2005).

In curriculum-supported learning, 'learning by playing' and 'learning without being aware of it' are the key (especially for the youngest). By means of quiz games (Attewell, 2005), brainstorming or voting via mobile devices with results being displayed at an electronic blackboard (Dawabi, Wessner and Neuhold, 2004) or projected onto the wall via laptop and video projector, and team-oriented outdoor (on site) experiments, variety is added to conventional lessons. Generally, this increases the student's motivation and commitment and helps maintaining their interest. Moreover, the chance to participate actively is enhanced for otherwise rather insecure and reserved students (Ng'ambi, 2005). Attewell (2005) and Attewell and Savill-Smith (2004b) reported that even students at the risk of dropping out of education or those who have already dropped out, homeless, young offenders, or apprentices can be attracted to learning.

In many developing countries, fixed line telephony is leapfrogged and mobile telephony adopted directly, so that also very poor and excluded groups are users of mobile devices (Attewell and Savill-Smith, 2004b; Freysen, 2004). The typically otherwise rather poor infrastructure and the dominating preference for oral communication have led to several promising mobile learning projects in higher education, for instance in South Africa (Brown, 2004 and 2005). In particular, administrative uses such as the access to learning records and marks, registering and checking attendance, as well as the download of learning material and the communication with teachers and peers are enabled. Mobile learning seems to have high potential in supporting higher education in developing countries.

In general, despite all benefits and reasonable (potential) fields of application, mobile learning should not replace conventional learning but rather be used supplementary to foster, facilitate and enrich the learning process. Technology should not be the focus of attention; concepts from educational research, social sciences and engineering have to be integrated into a holistic framework for mobile learning (Nyíri, 2002; Milrad, 2003; Sharples et al., 2005).

5 Conclusion

Mobile learning, though in its core nothing new, can be viewed from a different perspective in times of the 'knowledge' society and the increasing proliferation and ongoing further development of mobile ICT and the convergence of different ICT trends towards ubiquitous computing. Offering efficient means of collaboration, including communication, coordination and cooperation, the opportunity of more or less autonomous control of the individual learning process and the flexibility of learning anywhere, anytime and context-aware, mobile learning using up-to-date learning devices shows high potential in supporting lifelong and life-wide learning. In particular, m-learning is applicable to exploit niche times (occasional learning), to enable problem-led learning on demand, e.g. for travellers, and to enrich traditional curriculum-based

learning by adding variety to lessons and increase the motivation of students. Apart from the existing technological challenges that are predicted to be overcome in the near future, educational issues will have to be solved. At any rate, mobile learning is highly promising in complementing conventional ways of learning rather than in replacing them. It provides auspicious opportunities for individuals to acquire 'relevant' information and consequently knowledge irrespective of place and time.

Intended future research includes an empirical study to evaluate the potential of mobile learning for short-distance commuters, with a focus on urban areas. Attitudes towards and expectations of mobile learning offers, especially concerning learning during travelling and commuting, preferred learning settings, e.g. in terms of time, content, learning style (visual, auditory, etc.), usage requirements and the willingness to pay will be investigated.

References

Abfalter, D., Mirski, P.J. and Hitz, M. (2004) 'Mobile learning – knowledge enhancement and vocational training on the move', Paper presented at the *5th OKLC 2004*, Available at: http://delphi.jura.uni-sb.de/texts/mirski2.pdf (last visited April 4, 2006). In proceedings.

Andronico, A., Carbonaro, A., Colazzo, L. and Molinari, A. (2004) 'Personalisation services for learning management systems in mobile settings', *Int. J. Continuing Engineering Education and Lifelong Learning*, Vol. 14, pp.353–369.

Attewell, J. (2005) 'Mobile technologies and learning: A technology update and m-learning project summary', LSDA: London. Available at: http://www.lsda.org.uk/research/centres/RCFTechEnhanceLearn/mobile/ (last visited April 3, 2005).

Attewell, J. and Savill-Smith, C. (Eds) (2004a) 'Learning with mobile devices: research and development', Paper presented at the *MLEARN 2003*, LSDA: London. Available at: http://www.lsda.org.uk/events/mlearn2003 (last visited Dec. 20, 2005). In proceedings.

Attewell, J. and Savill-Smith, C. (2004b) 'm-Learning and social inclusion – focussing on learners and learning', *Learning with mobile devices: research and development,* Paper presented at the *MLEARN 2003*, J. Attewell and C. Savill-Smith (Eds), LSDA: London, pp.3–12. In proceedings.

Attewell, J. and Savill-Smith, C. (Eds) (2004c) 'Mobile learning anytime everywhere', Paper presented at the *MLEARN 2004*, LSDA: London. Available at: http://www.mobilearn.org/mlearn2004/index.htm (last visited December 20, 2005). In proceedings.

Baber, C., Sharples, M., Vavoula, G. and Glew, P. (2004) 'A 'learning space' model to examine the suitability of different technologies for mobile learning', *Learning with mobile devices: research and development, Proc. MLEARN 2003*, J. Attewell and C. Savill-Smith (Eds), LSDA: London, pp.21–25.

Brown, T.H. (2004) 'The role of m-learning in the future of e-learning in Africa', In D. Murphy, R. Carr, J. Taylor and W. Tat-Meng (Eds), *Distance Education and Technology: Issues and Practice*, (pp.197–216) Hong Kong: Open University of Hong Kong Press.

Brown, T.H. (2005) 'Towards a model for m-learning in Africa', *Int. J. E-Learning*, AACE: Norfolk, VA, Vol. 4, pp.299–315.

Burkhardt, J., Henn, H., Hepper, S., Rindtorff, K. and Schaeck, T. (2001) *Pervasive Computing – Technology and Architecture of Mobile Internet Applications*, New York: Addison-Wesley.

Carlsson, C., Carlsson, J., Denk, M. and Walden, P. (2005) 'Mobile commerce: insights from expert surveys in Austria and Finland', Paper presented at the *18th Bled eConference: eIntegration in Action*. In proceedings.

Chabra, T. and Figueiredo, J. (2002) 'How to design and deploy handheld learning', Available at: http://www.empoweringtechnologies.net/eLearning/eLearning_expov5.htm