Mobile Learning: Tendencies and Lines of Research

José Carlos Sánchez Prieto
University of Salamanca
Canalejas 169
37008 Salamanca, Spain
(+34) 923 294500 ext.
Josecarlos.sp@usal.es

Susana Olmos Miguelángel
GRIAL Research Group,
Research Institute for Educational Sciences (IUCE),
University of Salamanca
Canalejas 169, 37008
Salamanca, Spain
(+34) 923 294500 ext. 3424
solmos@usal.es

Francisco J. García-Peñalvo
GRIAL Research Group,
Research Institute for Educational Sciences (IUCE),
University of Salamanca
Canalejas 169
37008 Salamanca Spain
(+34) 923 294500 ext. 1302
fgarcia@usal.es

ABSTRACT
As mobile technologies have gained presence in all social groups, the interest for their applications in the educational field has grown steadily. The present article proposes an exploration of the concept of mobile learning with the intention of describing the possibilities of this methodology and establishing its development tendencies.

To that end, we will focus in three key aspects: didactic uses, pedagogical criteria and lines of research. We will begin with a definition of the key concepts and an analysis of the features of the devices, addressing the didactical implications of each one’s use. Secondly, we will address the pedagogical criteria for the integration of mobile learning (mLearning), and we will describe its connection with the different theories of education and we will establish the guidelines to follow when developing activities within this methodology. Lastly, we will present the main lines of research, with a particular focus on Europe and Spain. As a closure, we will pose a series of conclusions and proposals to improve the development of mobile learning as an educational solution.

Currently, research on the possibilities of mobile terminals in the field of teaching is focusing particularly on the development of a pedagogical framework from which to elaborate a proper didactic methodology. This article aims to reflect this growing tendency.

Categories and Subject Descriptors

General Terms
Theory, Design.

Keywords
mLearning, eLearning, pedagogical uses, didactic principles, mobility, ICT, trends, research in education.

1. INTRODUCTION
The field of the educational use of information and communication technologies (hereinafter ICT) is subject of continuous changes, linked to the fast technological development.

The impact of the technological innovation it’s even larger in the field of online training, continuously demanding immediate methodological changes [9].

Through the last decade we have seen how new related concepts have emerged and gained strength, such as eLearning, blended learning (bLearning) or, the subject of this article, mobile learning (mLearning).

mLearning arises due to the success of the mobile terminals in the various social strata and intends to explore the educational possibilities of these resources. It lies within the framework of eLearning and it is increasingly used as educational solution, with the aim of enabling the learning process anytime, anywhere.

Mobile learning has experienced a strong expansion in the last few years, with an increasing number of experiences and research on the subject made from a pedagogical and technological point of view.

In the present article we propose a review of the current situation of the mobile learning as an educational methodology and field of research.

The article is organized in five sections. In the first one we will establish a conceptual framework for mobile learning. We will continue with an analysis of the different devices that can be used in mobile learning activities and the didactic and pedagogical implications of this modality. The fourth section will present a description of the main lines of research, focusing on Europe and Spain. Finally in the fifth section we will offer a series of conclusions derived of the analysis.

2. WHAT DO WE MEAN BY MLEARNING?
Mobile learning is closely linked to the eLearning field. While this term can make reference to any teaching/learning process that makes use of electronic means, it is mainly used to refer to the learning process developed through the Internet, as this has become the basic tool for developing distance education processes [11].

Due to its relationship with technological innovation, eLearning has been branching out, giving rise to new methodologies that try to get the most of certain technologies. It is in this context that concepts like gLearning, eLearning or mLearning emerge.

Mobile learning can be understood in a variety of ways, depending on the element that we focus on. [46]:

- Learning through mobile terminals.
Learning with students that are on the move.
Learning through mobile content.

The existing definitions of mobile learning are different, depending on which of the previous contexts the author emphasizes, and depending on the established relationship between eLearning and mLearning.

Quinn [39] makes a first approach to the concept of mLearning, describing it as eLearning that takes place through mobile devices. This kind of definitions may make the mistake of being excessively technocentric. [48].

O’Malley et al. [29] propose a wider definition, considering mobile learning “Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies.” For this author it’s only necessary one of the two factors to be present in order to talk about mLearning.

Petrova and Li [2009] define it as “a ubiquitous learning activity occurring through person-to person communication using a mobile device which is supported by an appropriate mobile technology, user interface and a pedagogical approach”. Not only do these authors mention the technological component, but they also focus on the mobility, and they describe the three fundamental components of mobile learning: hardware, interface and pedagogical design.

Regarding the relationship between mLearning and the educational fields, Traxler [49] states that mobile learning is “essentially personal, contextual, and situated” and has been positioned inside the field of the informal learning, which constitutes an important obstacle towards its integration in the formal field of education.

In the debate about the role of mobile learning in formal education, there are many authors that consider it as a complement of presence-based learning. This is the opinion of authors Lauiris and Eteokleous [23], who rely on constructivist theories and reclaim the potential of mLearning for communicating and developing collaborative activities.

Mobile terminals offer many possibilities to students regarding communication and autonomous work. Thus, the line between formal and informal learning blurs, and this demands the rethinking of the traditional teaching strategies [45].

The development of mLearning and the widening range of opportunities to develop educational processes anytime anywhere will eventually lead to a new learning methodology: the ubiquitous learning or uLearning, learning every time everywhere.

In this methodology the student would find himself in a situation of permanent learning, surrounded of learning elements, to the point that the learning could even take place unconsciously [17].

This way, mLearning would be situated halfway between eLearning and uLearning.

3. WHICH IS THE MOST ADEQUATE DEVICE?
When it comes to determine which terminals are susceptible of being used to develop mobile learning activities, considering as mobile device any object with a processor with memory that has data input and output [40], there is a great variety of technological resources at the teacher’s disposal.

Below we present the characteristics and didactic uses of the most common devices, focusing on the two most important ones nowadays: smartphones and tablets.

As previously stated, smartphones and tablets are the most used and analyzed devices. However, there are other relevant ones that frequently appear in the bibliography [21] [36] [44]. On their article “Are you Ready for Mobile learning?” [5], Corbeil and Valdés Corbeil make a complete analysis of the following devices:

- **IPod and mp4 players**: Among the educational uses of this technology are the download and reproduction of audio and video files. In addition, it allows internet browsing. Unlike the iPads, the PDA supports collaborative learning by including communication tools and text processors. Their main restrictions are a lower technical power compared with the smartphones and the difficulty to handle mobile networks.
- **Ebook readers**: Ebook readers are used to store and read diverse text. Their design and the quality of their digital ink screens make them the most suitable terminal for reading. They allow underlining and taking notes, so they are useful for in-class working.

**Smartphones** are small size devices that combine the uses of the conventional mobile phones with those of a pocket pc [21]. They offer internet connectivity and a wide range of functionalities that go from the elaboration of documents and multimedia to the realization of web 2.0 activities.

The popularity of this resource has strongly grown in the last years, displacing the mobile phones [6]. Its main advantages are reduced size, autonomy, the provision of network connection anytime anywhere, and processor capacity.

**Smartphones** can be used in a broad set of mobile learning experiences, from game based learning activities [2] to the distribution of eLearning content [13].

Since the release of the first iPad in 2010, tablets have quickly spread in the mobile devices market. This resource composed of a tactile screen, generally between 7 and 10 inches, offers the same functionalities of a computer and it’s handheld without the need of external peripherals.

This device is especially useful in the development of mobile learning activities, helping to overcome the difficulties related to the small screen size and power of the rest of technological devices.

This technology allows amplifying the inherent advantages of mobile learning, facilitating the search and consultation of information, the interaction, and the adaptation to different learning styles [42].

However there are still gaps in the development of Tablet-specific educational software. After carrying out a study on the educational potential of the existing applications for iPad, Murray and Olcese [28], from the University of Pennsylvania, concluded that, although there was no doubt about the potential of these...
Mobile Learning: Tendencies and Lines of Research

Instruments, the software developed until this point didn’t take advantage of the new capacities of the device. Since then there has been important advances in this matter, specially noting the launching of Apple’s iTunes U, a tool for the elaboration and distribution of contents specifically designed for tablets [12].

The popularity of these two technologies has made more and more schools interested in implementing them [35].

At pre-primary level there are some interesting experiences, like the one carried out by Beschorner and Hutchison [1], who incorporated the use of tablets in the classroom. These authors explored the possibilities of iPads in literacy instruction through progressively complex applications that helped 4 and 5 year old children develop their oral and writing skills. Although the authors acknowledge the limitations of their study, they highlight the unique capabilities that tablets offer, especially their social component.

Hutchison, Beschorner and Schmidt-Crowford [15] had conducted a similar experience centered in Primary Education students, in which they also chose iPads for literacy instruction. They used different applications for activities such as independent reading activities (iBooks), identification of primary and secondary ideas in a text (Doodle Buddy), visualization (Popplet) or identification of cause and effect (Sundry Notes).

Kong [20] studied the possibilities of these mobile terminals in mathematical instruction at primary level. He used these terminals for sending information during the sessions, solving problems through the interaction with the application and as a communication and classroom control tool.

There are other studies with Secondary Education students, such as the one conducted by Mandula, Meda, Muralidharam and Parupalli [24], who studied the possibilities of sending lesson videos to the student’s terminals, or the one carried out by Kamaruzaman y Zaino [19] about the possibilities of the M-Language application for smartphones.

4. PEDAGOGICAL CRITERIA IN THE IMPLEMENTATION OF MLEARNING

In addition to constituting a new technology, mobile learning implies a new methodology that determines plenty of things, from the design of new didactic resources adjusted to the terminals and mobility, to the pedagogical principles that underline them.

To correctly develop a mobile learning experience, it’s necessary to adapt the presentation of contents and the activities to the characteristics of this methodology. This is only possible if we are conscious of the potential and limitations of mobile learning.

There are many characteristics that lead us to suggest the integration of mLearning in the formative practice. We would like to highlight some of them:

- **Immediacy:** mLearning allows the immediate application and publication of contents. This characteristic is enhanced by the combination of mobile devices and web 2.0 [38].
- **Multimedia:** The mobile terminals enable the integration of multimedia contents in the teaching/learning process. When used properly, they are important elements of motivation [41].
- **Personalization:** Mobile learning possesses a huge capacity of adaptation to the characteristics and context of any individual [49].

Although mobile learning can provide a wide range of educational solutions, there are some difficulties to overcome when it comes to designing our own activities. Orr [32] summarizes these key factors:

- **Technological difficulties:** The characteristics of both hardware and software carry a series of associated restrictions (difficulties in reading long texts, problems to produce long texts due to the text input method…). Although significant progress in the development of new features for these resources is being made every day, the technical barriers are still a problem, limiting the variety of activities that can be carried out. The appearance of the tablets has been an important advance in this matter, minimizing the problem by offering bigger screen size and more autonomy.
- **Dependency of the connectivity:** The terminal’s dependency on connectivity in order to carry out the activities is a factor that limits the mobility.
- **Difficulty of adaptation to the new mobile terminals:** The number and variety of mobile alternatives makes it necessary to perform a new process of selection and adaptation of the materials to the devices that are better suited for them.
- **Student distraction:** Due to the nature of the methodology, the mobile teaching/learning process frequently takes place in multitask contexts which difficult the student’s focus and may undermine the process.

Depends on the context in which the educational process develops, there is the risk of digital exclusion. Mobile learning requires of certain level of technological knowledge that may cause that the advanced users have certain advantage. Furthermore, the less advanced users may feel intimidated by this technology and stay out or feel isolated [5].

Although some of the factors previously mentioned are related to technological questions, most of them have to do with educational aspects and can be solved by implementing improvements in the didactic design of the activities [4].

The integration of the mobile devices into the teaching process depends not only on its general contributions, but also on their educational paradigm. Kadirire [18], expose how mLearning is related to the conductist and cognitivist paradigms:

- **Conductist:** Within this paradigm there would be activities such as the delivery of content through the use of text messages or stimuli-response based activities in which a reinforcement message is sent by the system after the student sends his answer.
- **Constructivist:** In this paradigm the students become builders of their own knowledge through the active
participation and the collaboration through their mobile devices and the communication support tools that they offer. The best example of this kind of activities is the participative simulations, activities in which a group of students simultaneously participates in a learning simulation.

Faced with these two paradigms, we agree with SCOPEO [44] when they state that mobile learning has a bigger development potential within the constructivist paradigm, given that “it’s conductive to a social interaction for the construction of knowledge, while allowing the student to build his own scaffolds for significant learning”.

Focusing on the application of the mobile technologies to the distance education process, we will take the transactional theory of distance education as a referent. This theory considers the distance as a pedagogical factor determined by three factors: the structuring of the program, the interaction between teacher and student, and the autonomy of the learner. [27].

According to this theory, we can classify the mobile learning activities in four groups [34]:

- **Social Learning activities with high transactional distance:** It involves activities in which there is a high psychological distance between the students and the teacher or institution and which have a highly structured content. They propose a group work methodology in which the interactions happen mainly between the students, and the teacher has a guidance role.

- **Individual learning activities and high transactional distance:** These are also activities in which there is a high psychological distance between the students and the teacher or institution, and a very structured content. However, in this case, the main interaction takes place between the learner and the content.

- **Social learning activities and low transactional distance:** It involves interventions with a loosely structured content and lower psychological distance between the student and the teacher or institution. The learners work in groups to solve a problem, and interaction processes are established in a natural way.

- **Individual learning activities and low transactional distance:** This are loosely structured activities with a lower psychological distance between teacher and learner. In these activities, the learners frequently interact with the teacher that monitors their learning process, trying to adjust the contents to their individual needs.

Based on the previously mentioned characteristics, we consider that the mobile learning designs must follow the following principles, elaborated on the contributions of SCOPEO [44], Elias [7] and Franklin [8]:

- **Accessibility and mistake tolerance:** It’s important that our activities have an intuitive interface that allows the rectification of navigation-related mistakes.

- **Multimedia:** The integration of multimedia elements in the mobile learning content presentation is a very important factor to consider due to the short duration of the modules.

- **Action oriented:** The mobile terminals aren’t a reflexive medium; therefore, the approach of the educational process must be practical and immediate.

- **Communication and visibility:** To use the connectivity and communication capabilities of the mobile technologies to carry out collaborative activities and facilitate the learners to share their contributions.

- **Constantly renewed and updated:** This aspect makes reference to the content and the methodology used. The evolution of the mobile devices is very fast and it produces new functions that could make the educational process easier.

- **Adapted to the features of the device:** That condition the type of activities that we could develop. It isn’t the same designing an activity for mobile phones than an activity for tablets, as there are important differences both on the available software and on the physical conditions of the terminals.

To be able to correctly design and develop mobile learning activities it’s necessary to ensure a teaching body with the adequate training. When it comes to training this teaching body, a series of requirements must be met [43]:

- Adaptation to an environment of rapid and constant changes.

- Knowledge of the new technologies and production tools.

- Interaction skills.

- Pedagogical skills.

### 5. THE RESEARCH ON MLEARNING: FROM EUROPE TO SPAIN

The research lines in mobile learning can be classified in three categories, depending on the focus of the investigation: technology, pedagogy or educational theory [37]:

- **Research focused on the technology:** They study subjects related to the usability of the mobile devices or the network transmission.

- **Research focused on the educational theory:** Related to the practical applications that these technologies may have within the educational theories.

- **Research focused on the pedagogy:** Dedicated to the design and evaluation of materials and their direct application. Their work has tangible products as a result.

In the analysis on the evolution of the number of researches inside each group performed by these authors, it was found that the majority of the investigations belong to the group focused on the technology, although the trend is the decrease of studies focused on this aspect and the growth of the number of investigations carried out by the other two groups, especially the third one.

Wen-Hsiung et al. [52] confirm this in their study where, after analyzing 164 articles, they concluded that the majority (58%) were centered in the evaluation of the effects of mobile learning. 32% were centered in the design of mobile systems for learning,
Mobile Learning: Tendencies and Lines of Research

5% in investigating the affective domain and the remaining 5% was centered in evaluating the learners’ characteristics.

Traxler [49] proposes a different classification of the investigations, focusing on the thematic:

- **Mobile learning centered on the technology**: A technological innovation is introduced in an educational context to measure its technological feasibility and educational possibilities.
- **Miniaturized and portable eLearning**: It involves implementing solutions already used in eLearning environments, after adapting them to mobile terminals.
- **Classroom connected learning**: To apply mobile technologies in the classroom to support collaborative learning. They may appear connected to other resources such as digital blackboards.
- **Individualized, situated and personalized Mobile learning**: Development and application of programs that help producing context aware educational experiences.
- **Mobile training**: The use of the mobile technology to improve the worker performance through the delivering of information and just-in-time support to attend their immediate needs.
- **Mobile learning in remote and rural environments**: Application of mLearning in distance learning experiences in places where conventional eLearning has no reach.

The majority of subjects proposed by Traxler revolves around adult education and is strongly linked to distance education.

In Europe, mLearning research began its development significantly with the explosion of the PDAs during the 90s. In those years, the studies were focused on the development of technologies (HandLeR), software architectures (MOBILearn) and service portals (mLearning).

With time, the number of investigations has increased. In Europe, the main characteristic of these investigations is that they are focused on the study of pedagogical implications. The subjects of research have been diversifying, including the following [22]:

- **Mobile learning in the schools**: With projects that range from the application of known technologies (Learning2Go) to the creation of specific applications and programs (Pl y Let’s Go).
- **Mobile learning in higher education**: They usually involve more participants than the rest of investigations and are overall focused on the use of SMS for the communication with the students, and podcast recordings (StudyLink). There are also experiences with students doing internships (myPad project).
- **Mobile learning in museums and informal contexts**: These are educational projects developed on informal education contexts. The majority of the projects use the smartphones as communication devices and to receive and transmit data.
- **Mobile learning in work environments**: Focused overall in medicine teaching (Knowmobile, Medimobile) and in situ competence development (Personal Mobile Assistant).

Although mobile learning in Spain is still at an early stage of development, there are significant experiences both in the public and private sectors, such as the programs of Ferrovial, AENOR y ASISA [44]. Within formal education there are some pilot experiences being conducted, such as Proyecto DEDOS, developed by the CITa (Center of Investigation in Advance Technologies) of Peñaranda de Bracamonte (Salamanca) in collaboration with the CEO Miguel Delibes de Macotera. The project’s aim is to study the use of tablets in the classroom [3].

Fernández López, Rodríguez Fórtiz, Rodríguez Almendros and Martínez Segura [10] developed a study about the possibilities of iPads in the support of students with special education needs through a platform of their own making called Picaa. The success of this experience has motivated the continuity of the platform and the project in partnership with other Special Education schools.

There are also other examples in the field of higher education, such as the experience conducted by UDIMA (Distance University of Madrid), which investigates the use of the iPad in distance learning [50].

The most significant case of mobile learning in Spain takes place in the EOI (School of Industrial Organization). The program has been in development since 2009, having taught more than 1,000 students. During its first edition they decided to use smartphones, but currently tablets have substituted them, because they adapt better to the needs of mLearning.

The program is based on the combined use of open software, virtual campus, collaborative tools, web 2.0 resources and social networks [47].

Currently we can find the following tendencies in mobile learning research:

- **Located learning**: The inclusion of geo-location capabilities in mobile devices allows the design of applications that relate to the location of the student [30].
- **Serious Games**: The screen resolution and graphics horsepower of tablets and smartphones allow the creation of interactive educational videogames [25].
- **Augmented Reality (AR)**: Another application of tablets and smartphones that is currently being explored is their use in AR activities. AR superimposes virtual elements over the image of real elements through the combination of the screen and camera of the devices, thus permitting the interaction between these elements and the students. AR has been explored in diverse educational contexts ranging from Primary Education [33] to University [14].
- **Interactive Books**: The use of tablets as a medium for interactive textbooks with multimedia content and interactive activities [16].

6. CONCLUSIONS

Mobile learning is a new training modality that comes to deepen the changes introduced by eLearning. It is a recent methodology based on the fast growth and development of the mobile technologies and their capacity to answer to the need for a more flexible educational process.

The research on mLearning finds itself at an early stage of development, where most of the investigations are focused on the technological aspect, and paying less attention to the didactic elements. However this trend is being modified, with the emergence of more investigations made from a pedagogical perspective.
We consider that is necessary to pay attention to the pedagogical research on mobile learning so we can develop more efficient teaching methodologies with these resources, because, as we have seen in other occasions, the mere technological development does not result in a methodological improvement.

The UNESCO [51] states that there is a stigma over mobile learning, a series of prejudices in the society, on a global level, that considers these terminals unsuitable for learning. Nevertheless, the different experiences have been demonstrating that this is not the case. A change of mentality is necessary, to make society realize this is a suitable alternative.

This change of mind must be based on the improvement in the quality of the mLearning programs, which depends on the appropriate development of the pedagogical approaches and the design of quality didactic activities.

7. ACKNOWLEDGMENTS
We would like to thank the Regional Council of Education of Junta de Castilla y León (Spain) through the projects GR47 and MPLE (ref. SA294A12-2). Finally, authors would like to thank the partners of GRIAL, http://grial.usal.es, for the received support.

8. REFERENCES
Mobile Learning: Tendencies and Lines of Research

(Compiling E-learning and m-learning: New applications of blended resources. IGI Global, Hershey, 151-177.


[61] Ramírez Montoya, M.S., 2009. Recursos tecnológicos para el aprendizaje móvil (mlearning) y su relación con los ambientes de educación a distancia: Implementaciones e investigaciones. Revista iberoamericana de educación a distancia, 12, 2, 57-82.


