Pervasive and Mobile Computing 14 (2014) 17–30

Contents lists available at ScienceDirect

Pervasive and Mobile Computing

journal homepage: www.elsevier.com/locate/pmc

To be or not to be *in situ* outdoors, and other implications for design and implementation, in geolocated mobile learning

Patricia Santos *, Davinia Hernández-Leo, Josep Blat

ICT Department, Universitat Pompeu Fabra, C/Roc Boronat 138, 08018 Barcelona, Spain

A R T I C L E I N F O

Article history:
Available online 12 September 2013

Keywords:
Mobile learning
Context-aware
Outdoors learning
Geolocation

A B S T R A C T

Fostering contextual learning *in situ* outdoors is one of the main opportunities favored by mobile computing. Of particular interest is the application of the Global Positioning Service (GPS) to geolocate educational resources. However, geolocating resources is not enough to support learning activities where students explore and interact with the outdoors physical environment practicing *in situ* related knowledge and skills. This paper studies the factors that have to be considered when designing, virtually or *in situ*, this type of mobile learning scenarios. Two experiments illustrate and analyze these factors. The results lead to a set of implications – in design, enactment and monitoring – for the development of mobile learning systems.

1. Introduction

Over the past decade, researchers have studied the benefits of using smartphones as appropriate tools for supporting Contextual Life-long Learning (CoLL) [1]. Sharples et al. define CoLL as the type of learning that happens when a person reflects on a current situation (occurred in a specific time/place) and has to resolve a problem, share ideas or to gain an understanding considering the context. In this line, Jeng et al. [2] provide a categorization of contextual m-learning activities, distinguishing between: (1) "*Everywhere/everytime activities*" benefiting from the ubiquitous mobility that smartphones have; and (2) "*Situated*" activities which have to take place in a specific physical space enabling the learners to reflect and learn about the environment by interacting appropriately with it.

In particular, focusing our attention on the categorization of situated m-learning, Hwang et al. [3] define the characteristics of this type of educational settings as: "context-aware u-m-learning environment", (i) it can be sensed, used to conduct an activity, and to offer adaptive supports; (ii) provides supports in the right way, right place, and at the right time; (iii) enables seamless learning within a predefined area; and (iv) is able to adapt the subject content to meet the functions of various mobile devices.

As we can observe in context-aware m-learning, the learning actions have to occur in specific real spaces which are connected to digital data. In fact, researchers mainly distinguish between indoors and outdoors m-learning activities [4,5]. Particularly, Rogers et al. refer to outdoor settings (e.g., parks, city centers, woodlands) and to indoor settings (e.g., museums, learning centers, labs, home). Basically, this distinction is based on: the architectural constraints of the space, but also on the type of technology that has to be employed to conduct the activity. Specifically, an *indoor space* is defined as closed physical space determined by the constraints of architectural components, such as walls, doors, corridors, floors, and stairs [6]. The inability of GPS to work effectively indoors makes impossible to use this technology as a location-based system (LBS) to mediate m-learning activities in this type of settings [7]. For this reason, researchers employ other location-based technologies

* Corresponding author. Tel.: +34 935421428.
E-mail addresses: patricia.santos@upf.edu (P. Santos), davinia.hernandez@upf.edu (D. Hernández-Leo), josep.blat@upf.edu (J. Blat).

1574-1192/$ – see front matter
http://dx.doi.org/10.1016/j.pmcj.2013.09.001

such as RFID, QR-Codes or Bluetooth to conduct indoors m-learning activities [8–10]. On the contrary, an *outdoor space* is typically an environment which is not limited by architectural boundaries, and where it is possible to receive GPS signal.

In this paper, we study the similarities and differences among diverse possible m-learning *in situ* activities which are mediated with GPS data and conducted in outdoors settings. As Rogers and Price [5], we also use the term "*in situ*" to describe context-aware/situated learning activities. As Hwang and Chang [11] identify, an important issue in m-learning is to develop adequate methodologies and tools to assist students to learn in a m-learning environment. For this reason, we claim that the characteristics of outdoors spaces determine the design method of potentially successful m-learning *in situ* mediated with GPS, and that the design process has an effect on the enactment and monitoring phases.

Within this context, we propose a categorization of outdoors m-learning *in situ* activities which is based on the design process: (1) *Designing virtually* and (2) *Design in situ*. In order to illustrate both types of activities, two real scenarios are presented and analyzed: (1) An experience was carried out with a group of students and teachers of a High School in Catalonia. An exploratory activity with 70 geolocated questions were conducted in the city of Girona with the aim of putting in practice skills and knowledge learnt in the Art History course. The students had to answer the questions that appear in their mobile devices when they were in specific positions. The teacher monitored the progress of the activity in real time. (2) The second scenario was conducted in the Botanic Garden of Barcelona. The teacher of the botany course, integrated in a university degree of Biomedicine, designed a route of 26 geolocated questions distributed over different parts of the garden. In this case, due to the characteristics of the space and the objects to explore, the design of the routes was first pre-defined by the teacher *in situ*. Students explore the botany garden, finding the corresponding plants, interacting with them in order to answer the questions. The results obtained from these experiments have been evaluated and analyzed to propose a set of implications which have to be considered during the design, enactment and monitoring phases of m-learning *in situ*. These implications can be used by developers to design appropriate m-learning *in situ* systems, and by practitioners as good practices to conduct these activities.

In both experiments, an extension of the QuesTInSitu system was used as the authoring tool and mobile app to design, enact and monitor the m-learning activity *in situ*. QuesTInSitu is a software implementation based on the IMS Question and Test Interoperability [12] and Google Maps to support formative assessment *in situ* [13]. Assessment *in situ* refers to a type of activity where the questions of a test have to be answered in front of a related real location taking into account the contextual information of the environment. During the edition of the route-test each question is associated with a real geographical coordinate. After conducting some experiments, the results presented in [13] have been used to improve QuesTInSitu. This paper presents the LBS functionality implemented in QuesTInSitu used to know the students' positions, manage the geolocated questions and monitoring the progress of the activity in real time.

In addition, this paper studies how the design process of assigning the educational resources (e.g. questions) to geolocated data differs depending on the characteristics of the educational setting (area and objects) which have to be explored by the students.

The rest of the paper is organized as follows. In Section 2, we present a brief review and discussion of the state of the art in m-learning outdoors that motivates the aims of this research. Section 3 introduces the QuesTInSitu system, and especially the mobile app and monitoring functionality. The evaluated scenarios are presented in Section 4. This section also explains and discusses the research questions and the results of the experiments. Section 5 includes the discussion and the proposed implications for m-learning *in situ* using GPS data in outdoors settings. Finally, Section 6 includes the conclusions and the future work derived from the contributions of this paper.

2. Learning *in situ* outdoors

Teaching outdoors has been studied in education even before the emergence of mobile technologies [14]. In fact, one of the concerns is how to include learning and assessment procedures outdoors in the educational curriculum. Typically, these activities have been categorized as *informal learning* activities, because their lack of instruction and alignment with the curriculum. As Hofstein and Rosenfeld [15] indicated: "*the main objective should be to create learning environments which allow students to interact physically and intellectually with instructional materials through 'hands-on' experimentation and 'minds-on' reflection.*" These authors studied how to bring the gap between formal and informal science learning (which we propose that can be extensive to other learning areas). They indicated that informal learning activities are done outdoors (out of the school), normally as optional activities, such as a supplement to formal learning. In fact, the authors proposed that informal learning experiences can occur in formal learning environments (e.g., schools) as well as informal learning environments (e.g., museums, zoos).

According to that, multiple authors [16,11,17–19] have provided evidence supporting that Technology Enhanced Learning (TEL) and especially the use of handheld/mobile devices offer the opportunity to explore and investigate other learning settings (e.g. outdoors spaces) in order to extend formal learning, usually limited to the classroom, into informal learning time. This means that this technology can be employed to blurry the boundaries between formal and informal learning. The inclusion of this technology, with an appropriate instructionalism, can connect the learning spaces (classroom and outdoors) and the learning activities which can be conducted in each space.

In order to conduct *in situ* learning activities outdoors it is necessary to understand how the students can interact with the space and objects of the selected environment Hwang et al. [3] propose twelve models (centered on students tasks) for conducting context-aware ubiquitous learning activities. As a summary, the main characteristics of these models are that