Design of a Mobile Guide for Educational Purposes

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ABSTRACT
Mobile technology keeps spreading over to new application areas, education being one of the more recent ones. Today, we already have a quite wide choice of educational tools for learners on the move. The tools and applications could be divided into those specifically or solely designed for educational purposes and software solutions operating on a multi-purpose device like a cell phone or a PDA. We present a mobile guide that works on any advanced cell phone or PDA. The guide can be used for path-finding or simple information retrieving but also as a learning tool for school children, students and cultural heritage tourists. We argue that usability design principles may clash with learner-centered educational principles, which means that a worse usability design may make a better educational tool.

Categories and Subject Descriptors
H.5.2 [**Information Systems**]: User Interfaces– *Design, Human factors*

Keywords
Mobile guide, mobile learning, usability, education through technology.

1. INTRODUCTION
Mobile guides have been a popular field of research and development activity because tourism and cultural heritage services seem to offer numerous opportunities for the so-called third generation (3G) mobile services. Since the existing 3G networks in Europe are not yet available for widespread commercial use, mobile services and applications for consumers, including those for tourists, are still few and often immature by their design. Mobile learning is also an area of increasing interest, as mobile devices, in particular mobile phones, have become commonplace. It appears that the early visions of m-learning are in line with constructivist pedagogical ideals. In particular, personalization, localization, and communication features of mobile technologies can help attain the central features of constructivist pedagogy.

Traditional usability approaches advocate principles that increase the ease-of-use of a system and enhance the performance of the user. However, the same principles fall short when designing for learning situations. In the case of learning situations, the design focus changes from the ease-of-use of the system and user performance to the understanding of the subject matter and support of the learning process. By applying a learner-centred design (LCD) approach, we ensure that we meet the learning objectives of a system.

In this paper, we present a mobile guide (M-guide) designed to support children in building a view of their region's cultural heritage, in the school context. The M-guide is a mobile multilingual multimedia application operating on a platform of geo-heritage information retrieved from a Digital Heritage Archive. We start with the state-of-the-art of mobile technology and mobile guides, in particular those designed for educational purposes. Second, we expose the theoretical background behind the notion of m-learning, the constructivist learning theory in particular. We will also show how this theoretical background is relevant for the application of a LCD approach to a mobile guide. Thirdly, we present the CHIMER project, the M-guide and elaborate on how design choices concerning the M-guide have been influenced by the LCD approach. We conclude by evaluating the trade-offs resulting from the use of learner-centred education principles, and how it has affected the design of our mobile guide.

2. MOBILE TECHNOLOGY
The information intensity of the tourist and travel industry makes it exceptionally well suited for the utilization of the latest ICT solutions. The technology of mobile guides is no exception, and most innovations in this area are being developed or already in use in tourism (see esp. Anckar 2002, p. 15; EC Statistics 2002; Buhalis 2003). Tourism and cultural heritage services offer numerous opportunities for the so-called third generation (3G) multimedia. However, the current technological infrastructure available for commercial use cannot quite yet support the realization of very advanced service and interaction concepts. With the exception of the city of London, the 3G networks in Europe are not yet available for widespread commercial use. The Finnish operators Radiolinja and Sonera started their 3G network trials already in August 2001, but the commercial use of the 3G networks in Finland will start only when the technology needed is of the quality that customers are used to. According to many industrial experts and consulting companies, the actual use of 3G services will be postponed until 2005. Consequently, mobile services and applications for consumers, including those for tourists, are still in their infancy. The situation is somewhat

different in Japan where the success of the i-Mode has given opportunities for extended and routine use of mobile services for some time now (see e.g. Teo & Pok 2003).

Bearing in mind the disillusionment that followed the first attempts to sell wireless application protocol (WAP) services, we have to ask whether mobile services will bring added value for the end user? Instead of searching for 'killer applications,' it would be crucial to know what things are perceived by the consumers to be valuable (Mobilocity 2001; Anckar 2002; e.g. Groot and Welie, 2002; Carlsson and Walden, 2002). However, due to a lack of empirical research it is yet largely unknown what makes consumers adopt mobile services (Pedersen and Nysveen, 2003; Anckar, 2002). Recently, research on m-commerce has started to focus more on the consumers' expectations and intentions than on the theoretical or actual technological potentials. When the technology has matured, the price is right and availability guaranteed, the users need yet to be persuaded of both the utility and the usability of mobile applications and services.

3. MOBILE SOLUTIONS FOR EDUCATIONAL PURPOSES

Mobile guides have been mostly developed for cultural heritage tourism, and for tourism in general (see Kray and Baus, 2003). A brief presentation of some existing mobile guides as well as mobile devices for educational purposes is given below.

LoL@ (Local Location Assistant) is a demonstrator of a mobile multimedia Tourist Guide (Pospischil *et al*. 2001). It accompanies visitors through the historical first district of Vienna. LoL@ is able to determine the user's position, offering him location specific content: multimedia tourist information, maps, and navigation. TellMaris focuses on tourists and the European citizen on the move. The main scientific objective of TellMaris project is the development of new technology to support interaction with 3D maps to retrieve tourist information on mobile computers. This will give the European tourist new means for search and retrieval of tourist information in a three dimensional space (Laakso *et al.* 2003). Cyberguide is one of the first prototypes for mobile context-aware systems for tourists. It is intended for indoor and outdoor use and works on a variety of handhelds. The experiences from the prototype have given early insight into what services context-aware mobile technologies could offer for tourists (Abowd *et al.* 1996, Long *et al*. 1996). MINERVA, tested in a Smithsonian museum in 1998, is an interactive museum tour-guide robot that guides people in the museum in an interactive manner (Thrun *et al*., 1999). Other documented mobile guides include for instance the AudioGPS (Holland and Morse 2001), CRUMPET (Schmidt-Belz *et al.* 2001), and REAL (Baus *et al.* 2001).

Instead of mobile phones and personal digital assistants (PDAs) (laptops and tablet PCs are not discussed here), one can use wearable devices for mobile educational purposes. De Freitas and Levene (2003) have surveyed a number of wearable devices that are presently on the market. IBM has developed an IBM Linux Watch which is a watch computer, with a wireless Bluetooth connectivity, supporting calendar scheduling, address book, to-do-lists and e-mail. Xybernaut Mobile Assistant is a learning device with a head mounted display unit, and its functions include location sensing, voice recognition and voice activation. iButtons are computer chips in a small container, and they each have a unique identification address. iButtons are used primarily for authentication and access control, which in educational contexts can be used for registration and access to classrooms and computers. The most elaborate wearable technology product presented by De Freitas and Levene is the MIThril vest, equipped with so-called Memory Glasses which is a proactive and context-aware reminder system.

It seems that the most obvious benefits of regular cell phones and PDAs over the more focused designs for mobile educational purposes are the good availability of cell phones and PDAs; the learners can be expected to have them, so that the educational institution does not have to invest in the equipment. Cell phones and PDAs can also be used for other purposes, which in case of more specific equipment is rarely possible.

4. MOBILE LEARNING AND LEARNER-CENTRED DESIGN

4.1 Constructivism

One could say that mobile learning has been wholeheartedly embraced by constructivist pedagogues because it is in line with the central ideas of the constructivist learning theory. Knowledge in modern constructivist learning theories is seen essentially as a social phenomenon; a social construct. Because the learner builds on his prior knowledge and beliefs as well as on the knowledge and beliefs (and actions) of others, learning needs to be scrutinized in its social, cultural and historical context. In other words, learning is a process of active meaning making and becoming a member of a certain community, in which the student is able to communicate and act according to its norms (Piaget 1975; 1982; Vygotsky 1969; Leontjev 1977; Engeström 1987; Tynjälä 1999; Järvinen 2001; Tynjälä *et al.* 2001; Johansson 1999; Poikela 2002).

Constructivist pedagogues underline the importance of a larger goal that organizes smaller tasks into a sensible whole, giving an incentive to take care also of the less exciting intermediate routines. Consequently, constructivist learning usually takes the form of a project (e.g. Pehkonen, L. 1994). Learning is not focused on separate facts but on a problem. The learner needs to feel that the problem in some way concerns him (i.e. to own the problem) in order to be motivated to try to solve it. The problem should also be close to a problem in the real world. When dealing with a real-world problem the student turns straight to information sources in the real world instead of trying to figure out what one would do if this were a real situation (see e.g. Kanet & Barut 2003:111; Leino 1994). Unlike in traditional teaching, in constructivist learning there is no one right answer but many possible solutions to a problem or at least, if there is one right answer, there are many alternative routes to it. The learning environment, too, should be in some sense similar to a real-world environment. This usually means going out from the traditional classroom, and learning things in their authentic environment (see e.g. Lehtonen 2002).

It follows from what has been said above that it is the learner and not the teacher who in a significant degree needs to take the responsibility for gathering knowledge. In constructivist learning methodology traditional teacher monologue *ex cathedra* is replaced by guidance, in which the teacher's role is to facilitate

learning by giving pieces of advice and guiding onto the right track. The learner's prior knowledge, experience and skills should be taken into account. Even if the learning materials was not something practical but facts or abstract concepts, the learner will better understand and remember them if they are built on his prior knowledge and experience. Constructivist education seeks also to leave room for alternative individual learning strategies (e.g. Ahtee 1994; Haapasalo 1994). Constructivists underline the social dimension of learning; all forms of interaction are encouraged, and usually assignments involve teamwork or other forms of cooperation. Because the learning process itself is more important than the outcome, the evaluation should focus on the process rather than the outcome (Björkqvist 1994). Lastly, because knowledge is not seen as something ready-made and static but an ongoing process, the learners need to retrace their steps and constantly revise their knowledge and skills in interaction with their environment.

4.2 M-learning

There are many definitions of m-learning. According to Tella (2003), m-learning refers to studying and communication in which different tools or mobile technologies are used. Sariola (2003) refers to m-learning as a situation in which a student utilizes mobile technology in his or her studies. Beyond the present-day hype associated with the development of modern mobile ICT, m-learning should be considered an opportunity to enhance the learning experience of learners, the main focus being on learning (or more precisely the process of learning: teaching-studying-learning) with mobile technologies.

As the concept of mobile learning is currently poorly defined (Tirri, 2003), several questions need to be asked; (i) what are the benefits brought about by mobility in learning environments? (ii) what principles should we apply in order to implement m-learning and reap its benefits?

Tella gives us some answers by analyzing the concept of m-learning from the perspective of pedagogy. It appears that the early visions of m-learning lend themselves remarkably well to the realization of the pedagogical ideals of constructivism, as briefly described above. In particular, personalization, localization, and communication features of mobile technologies can help attain the central objectives of constructivist pedagogy. Tella also interprets m-learning in terms of cybertextuality (as presented by Aarseth, 1997): through mobile cybertext, the mobile learner is empowered to experiment, navigate, choose and interpret the information he or she needs.

4.3 Learner-Centred Design

Traditional usability approaches offer principles that improve the ease-of-use of a system and the user performance. Nevertheless, the same principles fall short when designing for learning situations. In learning situations, the design focus changes from ease-of-use and user performance to the understanding of the subject matter and support of the learning process. Learner-centred design (LCD) is an approach that draws from human-computer interaction (HCI) research, psychology and education in order to develop software and systems that meet the special needs of learners. Consequently, knowledge of learning theories is required in order to derive solid principles for LCD. Quintana *et al.* (2004) outline two main learning theories, from which LCD principles can be derived: behaviourism (learning involves programming of learners to adopt a specific behavior) and constructivism. For the purpose of the mobile guide that we present here, we are primarily interested in the constructivist approach and the LCD principles derived thereof. The main reason for this is that one of the intended application areas of our mobile guide is children using the mobile guide in a cultural heritage territory, applying a "learning by doing" approach: this context is strongly supported by the features and principles of constructivist pedagogy.

The implications of the constructivist approach for software design is that software tools should support active meaning making and scaffolding by learners. Reiser (2004) stresses the importance of "structuring and problematising" as one design principle ("just enough" support, in Reiser's words): we strive to engage the learner in a mindful activity and we encourage and support the user to address (and not to avoid) obstacles. In other words, we do not make the learning activity too easy nor remove all the thinking (this stands in contrast with traditional usability principles, where ease-of-use and performance are of primary importance to the designer).

Quintana *et al*. (2004) mention that LCD principles should be articulated around three main learning support strategies: (i) sense making, (ii) process management, (iii) reflection and articulation. Principles related to sense making emphasize the use of language, models, tools and artifacts around the subject matter, so that the learner can identify the information and relate it to the subject to be learned. Principles related to process management support ensure that task organization and complexity match appropriately with the cognitive demands of the learning process. Reflection and articulation principles secure provision of reminders and guidance to facilitate the two previous learning strategies.

5. DESIGN OF A MOBILE GUIDE IN CHIMER

5.1 CHIMER

CHIMER (Children's Heritage Interactive Models for Evolving Repositories) is an EU-funded project running 2002-2004. The purpose of CHIMER is to study and develop tools and methods liable to encourage schoolchildren across Europe to participate in building a living mobile view of the cultural heritage of their villages, towns and regions. The project intends to combine the didactic and organization expertise of teachers, museums and libraries with technical partners familiar with the latest developments in multimedia compilation and delivery in a mobile environment.

Involving children in the creation of a Digital Heritage Archive implies the development of a learning methodology. Children are becoming increasingly familiar with information technology, at least in gaming and communication activities; but for the purpose of CHIMER, knowledge of a wide range of software applications (text, web content and multimedia editing) and devices (scanners, digital video, cameras, GPS tools) is needed. CHIMER intends to produce a cognitive learning method based on "touch-and-learn" principles. Children will learn through their mistakes under the guidance of their teachers, technicians, and museologists. Learning takes place in real time, encouraging the children to feel comfortable with the technology. Taking into account the fact that

children are fast learners, the methodology developed throughout the project will enable children to obtain advanced skills in IT in a short time. These skills will be used for creating digital content.

The Digital Heritage Archive is a new open platform for storing heritage content in different forms. It is open and evolving, because it will be ready to be enlarged by any user who will join the existing network of schools, cultural institutions, and other members of the CHIMER network. Museologists, together with children, will select the heritage objects of interest to be digitized, and they will develop heritage information associated with each object. This heritage content will be ready for access by the newest generation of mobile technology and devices; we now speak of the notion of mobile evolving cultural heritage.

5.2 E-guide and M-guide

Two applications are created to access digital content stored in the Digital Heritage Archive platform: E-guide and M-guide, as illustrated in figure 1.

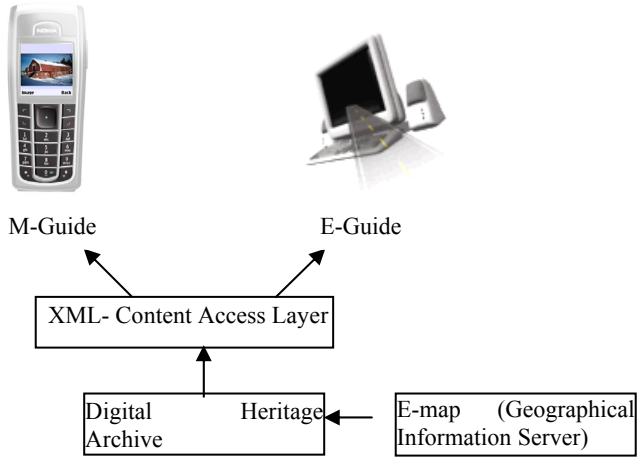

Figure 1. Architecture of the Digital Heritage Archive Platform

The E-map is a tool for retrieving geographical information through digital and mobile devices. When creating digital cultural heritage content, children and museologists also collect geographical information related to the cultural objects of interest. This geographical information may be GPS coordinates or routes, for instance. This data is stored as a vector map of the selected territory. This information, when combined with the digital cultural heritage content, enables the creation of geo-cultural content accessible by mobile devices.

The E-guide is the first application developed for CHIMER. It is a multilingual multimedia application operating on a platform of geo-heritage information (a combination of the E-map and the Digital Heritage Archive). The E-guide includes maps of the territory, multimedia CLIOs (Cultural Learning Interactive Object), photo galleries, on-line games, tourist information.

The M-guide (mobile guide) is the second application developed for CHIMER. The M-guide can be understood as a mobile version of the E-guide, exploiting the specific features of mobile technologies. In a sense, the M-guide offers a new way to access and retrieve cultural heritage from the Digital Heritage Archive linked to the E-map (see figure 2).

Figure 2. Screenshots of the M-guide.

The M-guide is a wireless, personal, multimedia, system for accessing information services focused on geo-heritage and retrievable through mobile devices.

The following user scenario illustrates a learning situation where pupils use the M-guide outside of the classroom in an authentic environment: "a class of pupils, equipped with mobile phones or PDAs, take a tour in the Vanhalinna museum area. The teacher assigns them objects of interest to study, say, a building, and their task is for instance to figure out how to locate this building on a map. This task has been integrated with other learning objectives in the fields of biology (a bat is living in the attic), history (built in 1927), geography (longitudes and latitudes) and so forth."

5.3 Usability Issues and LCD Principles in CHIMER

User experience and goals – such as fun, rewarding, motivating, entertaining, enjoyable – (see Preece *et al*. 2002) proved to be beneficial and easy to implement for the E-guide, but harder to incorporate in the M-guide, although teachers reported that children enjoy learning with mobile devices. The design of the M-guide is challenging as we aim to support the main user group, which consists mainly of children between 10 and 14 years old (on designing for children see e.g. Oosterholt *et al*. 1996), but we also want the M-guide to be accessible by a wider user population, which would consist of teachers, museologists, parents, and tourists. Children use the M-guide to learn about subjects such as history, geography, natural sciences and culture. As a consequence, we had to deal with several trade-offs when designing the M-guide; often it appeared that a "worse" design could work better than an optimal usability design to achieve the learning objectives set in the CHIMER project.

Let us take a simple example which illustrates how a "worse" usability design works better in terms of the LCD. In the first row of screenshots below, pupils use the mobile guide to open a position, which corresponds to GPS coordinates. The second screenshot shows that latitude and longitude can be entered using two input fields. The third screenshot shows the input field and a label explaining in what format the coordinate should be entered (DDMMSSssH). This design is very effective in terms of performance: it takes 24 user actions to input a set of coordinates. The second row of screenshots explains how the same functionality has been designed from a different perspective: the coordinates have been divided into smaller chunks of information (DD, MM, SS, and ss, instead of a numerical string as in the first design). Each part of the coordinates can be edited separately. This slows down the interaction in terms of performance: a

minimum of 40 user actions are needed to input a set of coordinates (see figure 3).

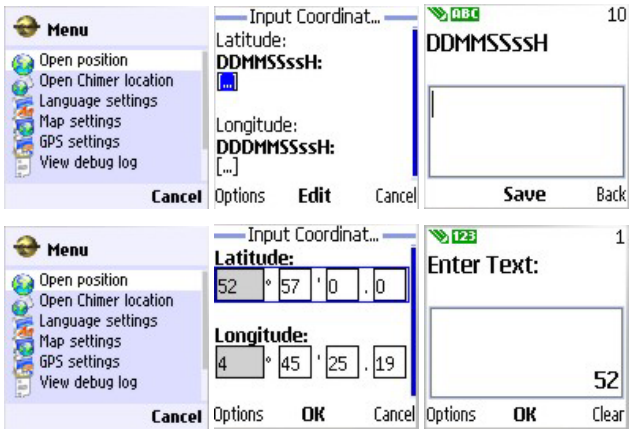

Figure 3. Design Alternatives for Coordinates Input

From a performance viewpoint, the first input mechanism is much better. However, the second solution is preferred because the concept of coordinates can be better understood by young children, if the coordinates are divided into smaller parts (the input field used in the third screenshot of the first row could suggests that a coordinate is a numerical string, and not degrees, minutes, and seconds).

The above example illustrates how we try to follow principles outlined by Quintana et al. *Sense making* is enabled by providing a structure for coordinates input that uses representations and language used by experts in the domain. *Process management* is supported by reducing the complexity of coordinates input task through ordered task decomposition. The number of user actions could be reduced to 30-35 user actions if we would optimize the input mechanism according to this principle; however this would imply using a system-driven prescriptive step-by-step input approach, thus reducing the user freedom to browse among the input fields and edit them. Consequently, this shorter and easier input mechanism was not chosen because it would have undermined the learning objectives.

6. CONCLUSION

Mobile guides are mostly designed for simple information retrieving and path finding for tourists. In this paper, we have presented a mobile guide developed in the CHIMER project, and analyzed its suitability for mobile learning purposes.

The design of a mobile guide for CHIMER is challenging as the learning objectives of the main user group come strongly into the picture and lead us to make design trade-offs. We argued that traditional usability design principles might clash with learner-centered educational principles, which means that a worse usability design may make a better educational tool. This raises the question whether – due to the design trade-offs – our mobile guide will become less valuable for cultural heritage tourists, which have been singled out as the second major user group of M-guide.

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