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MOBILE LEARNING - REVIEW OF THE LITERATURE

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Mobile Learning - Review of the Literature

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Abstract

In this paper I do a review and try to make a classification of the existing ongoing work on mobile learning according their thematic span of the projects and to their research goals. This gives an overall view of the m-learning domain and shows that researchers are still wandering on how m-learning will help reaching the goals of a better learning, and how it will be different from the rest of e-learning.

1. Introduction

The use of computing technology for learning has been observed in various ways, but since the recent years quick advance of mobile technologies a new term has appeared – mobile learning. Mobile learning is a field which combines two very promising areas – mobile computing and e-learning. M-learning has been considered as the future of learning or as an integral part of any other form of educational process in the future. As 'm-learning is quite a new domain there is a lot of work and research that is being going on. People are trying to understand *how* the mobile devices will help in reaching better education.

2. Ongoing Projects

The domain of mobile learning can include a wide variety of applications and new teaching and learning techniques. A mobile learning could be considered any form of learning (studying) and teaching that occur through a mobile device or in a mobile environment. Different devices that exist and all the devices that are coming up on the market, with their limitations and advancements, provoke different ideas for applying them on learning, thus any device can mean different m-learning.

2.1. Research on the Pedagogical Side of Mobile-Learning

Since the term m-learning appear for the first time lots of research is being done to investigate the cognitive and pedagogical aspects of the usage of mobile devices in education. Investigation had been done also on how useful mobile computing devices could be for reading or for workplace activities [45], on the basis of studying activity theory. Some authors [29] try to give directions to application designers for the areas, where the mobile devices should be most useful, how and why, according to their experiences with children. Other [28] are trying to achieve conclusions by analyzing the theories of adult informal learning. In some papers some interesting positive sides of using new technologies are underlined i.e. the participants are excited and want to try "new" things. Some findings show that introducing new forms of teaching (even if this means just using a standard tool for drawing on a PDA) make students spend more time in working on that subject, comparing to the other subject. Also overall students' results are becoming better [7]. Meanwhile the new technology gives new chances to students and to teachers to train their ingenuity [22] – students experiment with new tricks and ways to cheat and teachers should meet the challenge. The evaluation and the analyses of m-learning projects until now show mainly positive results. On the other hand there are some doubts if this excitement is, or is not, a temporary side effect. Most of the researchers think ([18][44]) that PDAs and other mobile devices should be seen more like extension, rather than replace the existing learning tools. Moreover not all kinds of learning content and/or learning activities are appropriate for mobile devices [14].

2.2. Courses for Mobile Devices

The most obvious use of mobile devices for educational purposes is a direct application of the e-learning techniques on smaller devices instead on a desktop PC. For grown people studying a subject is by default is arranged on courses, lectures, classes, etc. A logical sequence is the development and experimentation on transforming traditional courses in a form appropriate for mobile devices. Few different bodies are working in this direction.

An m-learning project concentrated on the testing of the use of WAP technology in higher education is the *UniWap* project ([30][32][31][33]). The team tries to explore the process of creating an operating environment for studying and teaching through smartphones and WAP phones. The Virtual University needs to support the

mobility of the participants of the learning process (the students and also the teachers). One phase of the project was to create some working prototypes (courses modules) and to investigate the problems and the value of such courses. The positive results they encountered (easy to develop, willingly accepted and widely used modules) encourage them to continue investigating the new coming technologies – digital imaging with mobile devices, 3G, etc.

At Ultralab *M-Learning* project the team is producing m-learning materials for people with literacy and numeracy problems ([3][41]). The great potential is encountered from the cognitive and pedagogical point of view, but as the development is quite trivial (Macromedia Flash), I will not discuss it in details. Once again the preliminary conclusions are that new technologies have great impact on students' interest in the subject studied. In this case this was one of the main wanted repercussions.

"From E-learning to M-Learning" [14] is a long-time project that aims to create a learning environment for wireless technologies by developing course materials for range of mobile devices. A discussion about the characteristics of the devices that are proper for learning is made when taking the decision what devices to use in the project. An analogy and differentiation is made between e-learning, d-learning (distance learning) and m-learning and in this context they try to foresee the future of m-learning and the methods and technologies that should be used for successful m-learning.

In their tries of finding the best way to apply mobile devices in education people are experimenting with different fields and one of them is language learning. At Stanford Learning Lab [24] an exploration of mobile learning has been done by developing prototypes that integrate practicing new words, taking a quiz, accessing word and phrase translations, working with a live coach, and saving vocabulary to a notebook. They envisioned that a good approach would be to fill the gaps of time by short (from 30 seconds to 10 minutes) learning modules in order to use the highly fragmented attention of the user while on the move. The research indicates some very useful directions, like the length of the learning materials, the personalization of interaction and the frustration of the user and the decreasing of the perception of the learning materials because of the poor technological implementation (i.e. the technology is not advances enough to use automated voice-controlled navigation through the materials; poor cellular connections and environmental noises can cause imperfect voice recognition, etc.).

Other projects are being in progress for creating special learning content for PDAs and WAP and also for developing special programs (like organizers, timetables and etc.) to assist learning with mobile devices.

2.3. Instant Messaging

One of the most straightforward application of the usage of mobile devices as educational supporting tool is messaging. Again few different educational bodies made experiments in this area.

At Kingston University (UK) an experiment was undertaken to research the effectiveness of a two-way SMS campaign in the university environment [39], [38]. The team has developed a system that sends SMS to students, registered to the service, about their schedule, changes in it, examinations dates and places, student's marks and etc. After registering the students were automatically separated in 5 different groups. One group was receiving announcements via e-mail, other 3 groups via SMS (but different interaction was necessary in every group) and the last – via web. The conclusions of the experiment were that the students in certain scenarios where a certain type of response is required preferred SMS as a medium to e-mail or web-based announces. They feel the data is more personal and they like this. SMS could be efficiently used in education (m-learning) as a complementary media. As the technology improves (i.e. EMS and MMS, potential more user-friendly interface) the potential increases too.

At the University of Helsinki the *LIVE* (*Learning In Virtual Environment*) experiments, made with SMS system and with WAP phones, were very positive [34]. The project went on by introducing digital imaging and sharing photos between the participants (teachers). The conclusions were that it is very possible that the introduction of MMS and the other 3G services in the large scene will lead to more and more possibilities for m-learning.

Another project [10] on evaluation of a Short Messaging System (SMS) to support undergraduate students was done at Sheffield Hallam University. The experiment was with 67 undergraduate psychology students. The implemented system was again not for learning, but for managing learning activities (to guide, prompt and support the students in their learning). The findings were overwhelmingly positive, with students perceiving the system to be 'immediate, convenient and personal'.

Positive results were underlined and after the outcomes from a survey in Norway - almost 100% of the students in that University have cell phones and SMS system would be widely accepted [6]. Once again an SMS system was considered to be used to spread information about lectures and classes, corrections in the schedule and etc. In certain cases students find it more convenient than e-mail or WWW as the information this was comes always on time.

These projects open two very important issues to be considered in doing further research in the mobile learning domain. The first one is that the current technology gives enough powerful instruments to support

some new forms of auxiliary learning tools. They also show the enthusiasm of the students to accept such new technologies.

2.4. WAP Portals

Ultralab *M-Learning* project [42] is one of the projects that have a special section dedicated on creation of a WAP portal for educational purposes. The technical aspects in the creation of a WAP portal for educational purposes do not differ from a common WAP portal. As the target users for this project are young people (age 16-24) with literacy problems, the group studies the problem of keeping the interest of the young adults to the useful learning materials, by exposing also modish and exciting subjects. Once again the pedagogical aspect of education is observed.

The positive results of many more systems, developed to combine WAP courses and SMS notification systems, were published by different universities in the last couples of years. Few examples of them are *HyWeb* [13] at Griffith University Gold Coast, *mid-2000* [43] at Minnesota State University, in Canada the *NAIT m-learning* project [25], and etc.

2.5. Tourist and museum guides

Tourist and museum guides are often considered as applications in mobile learning domain. They usually refer to newest technologies as location-discovery via GPRS, radio frequency or etc. Part of the already mentioned Ultralab project, is a project called *LAND* (*Location Activated Nomadic Discovery*). It explores the possibility to deliver media-rich context-aware information through mobile devices [40]. The generation of 3D landscapes, based on actual position of the mobile device and on additional information could be a useful educational tool. For example students can go in a picnic in the mountain and then ask the system to generate the view of their current position but in the ice age. Of course the use of such application could be more general (not only for educational purposes).

Tourist information could be considered as educational, so almost any tourist supporting system could be mentioned in the m-learning domain, but I think it is already differentiated as a separate field of research, so I will not talk about it more here.

The Electronic Guidebook [12] is a project, in which mobile web content was specifically created for the Exploratorium museum (an interactive science museum) in San Francisco. Several recurring issues and themes emerged from the analyses such as users' sense of isolation and user attempts to make a seamless experience between real-place and virtual contexts. Teachers felt the mobile web content would be more useful as learning activities before and after museum visits. While majority of users expressed a concern that the handheld would interfere with exhibit play (one hand is always busy in holding the device), these users also reported positive feedback about the mobile web content and demonstrated new ways in which this resource motivated new ways to think and play with exhibits.

A little different experiment was made for a museum in Japan [19], where an interactive guide system was created to familiarize the kids with exhibitions and to attract users' interests by allowing them to interact with the corresponding virtual exhibition on a sensing board, and providing them with its information. The system uses a sensing board which can rapidly recognize types and locations of multiple objects by using RFID (Radio Frequency Identification), and creates an immersive environment by giving users visual and auditory feedback to their manipulations on the board. After analyzing the acceptance of the system the team found that students, kids, but also their parents (surprisingly) enjoyed the system and think it is very useful.

2.6. Lifelong, collaborative or problem-based learning

One of the biggest initiatives in the m-learning domain is the one of University of Birmingham – the *HandLeR* project [11]. The project tries to understand in depth the process of learning in different contexts and to explore the lifelong learning. The stress is on communication and on human-centered systems design. The main concepts they investigate are concept mapping and knowledge sharing, lifelong learning, wearable learning technologies and conversation between mobile learners.

Similar in some concepts to *HandLeR* is the project undertaken at the Tampere University of Technology (Finland) [15], where PDAs are used for lifelong learning (mathematical education) of children. The study-content is presented in the form of a game (again the idea of human-centered education is explored) where the pupils can communicate and help each others and the electronic device is used to measure the average students' knowledge level and to adopt the speed of presenting new material to the learners'.

To support "Problem-Based" Learning was the aim of *KNOWMOBILE* project in Norway [36], where PDAs and smart-phones were used for experiment in medical education of students from the School of Medicine at University of Oslo. The students were put in different environment and were given different devices (some of the students were living together and were having PDAs with possibility to connect to each other; another group of students were able to connect between each other via internet but were working in separate location, and so on). After few weeks of experiment the team found out that the students are using the devices mainly to read information from the digital medical handbook (not to

retrieve it via internet as was expected) and as communication device (to discuss problems with colleagues but mainly for sending SMS messages and to organize social events after hours). The research (interviews) found that the reason for this was that even the medical students were eager to test the PDAs and investigate how they can be useful in learning they still had some technical difficulties. With proper guidelines and education the students could make it better so these problems are easy to overcome. The next generation devices will help a lot too. They concluded that the PDAs should not be regarded as Personal Digital Assistants, but rather as gateways in complicated webs of interdependent technical and social networks.

Research on new forms/tools for collaboration is been going on in different institutions, schools and Universities. In few different projects people are experimenting on the collaborative conceptual mapping and notes-taking systems ([16][23]). An example of such collaborative work is a project that took place at MIT [17]. The team uses PDAs to simulate the real environment (in the form of map) and to use simulation for a game, played by kids. They use PDAs equipped with GPS extensions. The idea is that the virtual world simulated on the PDA (which has the same geographical characteristics as real world) is "polluted". Kids have to take "virtual" probes from the water and/or air in the polluted area or surroundings, analyze the results, interview people and read information about similar situations and finally find out how to sublimate the environment. During the game they collaborate by doing different probes and analysis and giving the results (reports) to their classmates or leaving them (probes and reports) in a certain place in the area (map), where other kids can find and use them. The kids have to collaborate because they are forced by time limitations.

Advanced wireless technologies (IEEE 802.11, Bluetooth, and GPRS) are used in a project for development of ad-hoc classroom and *eSchoolbag* system at the Aletheia University in Taiwan [2]. The so called "Paperless education" is being observed together with the acceptance from the students (the term "paperless education" and research on the topic is made also in [27]). The traditional classroom was replaced by the new developed electronic tools (electronic blackboard, rubber, color chalk and so on). Pupils were strongly encouraged to communicate and to learn together (in groups).

2.7. "K12 classes"

In USA the usage of mobile devices by students in K12 classes is widely explored. One of the specifics of the education in K12 is that kids get lots of assignments for collecting data "on the field", for example making questionnaires and collecting few dozens of answers or taking measurements from the temperature near the school, etc. Applications for recording the data and taking notes had been developed for Palms and the pedagogical effect of them is analyzed ([35][1][8]).

Another specific is the usage of TI-83 (a specific science calculator) by more than 80% of the students in US schools. This fact predisposes specific experiments in the classrooms. An example are the experiments with networked TI-83 prototypes that were made in few schools in USA in the math classes [5]. A wired network of series of hubs that were connecting groups of 4 connected handhelds to other such groups was assembled. After revising the acceptable level of reliability in the classroom another prototype version was made. The system had a database server to cue activities and individual student data. It was composed on wireless hubs and an access point which connects students' handhelds with teacher's PC. Using this system students ware involved in group activities. The results of their work (for example the results of an equation) were anonymous (for the students in the class) and in the same time the teacher (on his/her PC) could see right in the classroom who made the mistake and why. The evaluation was made by series of interview of students about their opinion of the usefulness and friendliness of the system. Students find the system very useful; they think that it gives them freedom and comfort - they don't feel ashamed if they don't know the answer and they see that there are other students that have difficulties in understanding. Teachers find the system very useful too. Students became more active in the class and the new technology gives them (teachers) the opportunity to receive feedback right in the classroom and concentrate on things that are difficult for students to understand. Individual students' results (grades) also rose. The research group from Texas Instruments found this experiment and intends to continue doing their research to find out and to make explicit which design elements of a classroom network have a positive impact on the learning environment.

Similar experiments were made in Taiwan [21], where students were equipped with network-connected PDAs and their achievements were shown on a whiteboard. The results from the pedagogical point of view were again very positive (as the students were very shy they preferred to keep quiet and the teacher could not find out the real level of their knowledge). Compared with traditional classrooms virtual environment and technology motivate more participation and collaborative dynamics between instructor and learners.

There are also projects (as *COPE* at The University of Texas at Austin [20] and already mentioned *UniWap* project [33]) which observe the use of PDAs in teachers' productivity. The teachers can use the mobile devices to organize their work, keep track on students' performance for long periods of time (i.e. 7 years), but also to analyze their own work and the work of their colleagues by observing pictures, made during lectures.

3. Conclusions

The overall view on the existing research work and projects in the m-learning domain shows that it most probably applies best to processes, where specific knowledge should be retrieved/accessed in a certain moment, where discussions in distributed groups (i.e. brainstorming) appear, where data is collected or utilized "on the field", and where context-information is strongly related to the learning content. The nature of mobile devices, with their small screens and poor input capabilities leads to the assumption that they can not replace the standard desktop computers or laptops. But the same properties can make them efficient in learning domain, if certain constraints are kept ([14][24][37][9]):

- Short, not more that 5-10 minutes long modules. The participants should be able to use their small fragments of waiting time (i.e. waiting for a meeting or while traveling in a train) for learning, like reading small pieces of data, doing quizzes or using forums or chat for finding answers to "on field" questions.
- Simple, funny and added value functionality. The computational power and other properties of mobile devices make it difficult to use complex and multimedial content. It should be possible to use an m-learning system without having to read a thick user manual and one should find it more interesting or necessary and useful (or at least equally) to study using this m-learning system in his/her 5 min. break than playing a game on the same device.
- Area/Domain specific content, delivered just in time/place. The mobility should bring the ability to guideline and support students and teachers in new learning situations when and where it is necessary. The dependency of the content can be relative to location context (i.e. the system knows the location where the learner resides and adjusts to it), temporal context (i.e. the system is aware of time dependent data), behavioral context (i.e. the system monitors the activities performed by the learner and responds to them adjusting its behavior) and interest specific context (i.e. the system modifies its behavior according to the user's preferences). Of course a mix of the contextual dependencies is possible and likely.

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