Mobile Learning Environments – Educational report

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Introduction

This report aims at targeting issues that future developers of mobile learning needs to take into consideration and deal with, before designing mobile learning applications for the Nordic School system. The report builds on the knowledge derived out of the Mobile Learning Environment (MLE) project where applied research, tests, interviews and surveys have been carried out in Sweden, Denmark and Finland during 2007 and 2008. It also builds on top of prior work within the field of mobile learning.

Starting from relevant learning theories, various aspects of the learning content and its relation to mobile technology is discussed in this report. Collaborative learning and learner generated content is also discussed and amplified. The importance and necessity of a thorough integration of mobile learning applications in the formal school setting is highlighted, with special reference to the desire of teachers to be in control. Finally, aspects of inclusion and participation are analyzed, paying attention to students with different cultural background and students with reading and writing difficulties.

Project background and motivation

This report is one of three outcomes of the Mobile Learning Environments (MLE) project. The MLE project is financed by the Nordic Innovation Center and is carried out by a broad consortium from universities, businesses and government organizations. Within the project pedagogical game-like exercises have been designed for three different technical platforms for the primary school systems of the Nordic countries. The platforms have been tested in Sweden, Denmark and Finland and have been compared in order to provide research data from three perspectives, education, business and technology. The results of the project are guidelines and recommendations for businesses wanting to enter the market of mobile learning, for educators wanting to use mobile technologies, and for developers wanting to design future pedagogical tools and material. Apart from this pedagogical report, two other reports have been written, a business and a technical report. For more in depth analysis and knowledge around the project, several reports and research papers have been produced during the project and are available at the project webpage, www.m-learningenvironmens.com.

The material presented includes student evaluations of the mobile game prototype “MathX: The Search For Ancient Wisdom” a mobile learning environment application aimed at students aged 14–16 [1] which was created as part of the projects applied research methodology. During game play sessions in Sweden, Denmark and Finland, a number of teachers have also been interviewed and their views give important additional insight. Results from the MLE project have been presented at several of national and international meetings for teachers, school officials, and researchers. During these occasions valuable comments and advice focusing different aspects of mobile technology in school have been put forward. These comments are included in the report. Key persons implementing new technology in schools are young teachers belonging to the Internet and gaming generation. During the course of the MLE project teacher students have been working with mobile technology to collect data and construct content for educational purposes. Their reflections and comments have therefore been invaluable.

In the Horizon report series of the New Media Consortium and the Educause Learning

Initiative, 175 Advisory Board members in the fields of business, industry, and education seek to identify and describe emerging technologies likely to have a large impact on teaching, learning, and creative expression with learning-focused organizations. The 2008 report singles out mobile devices [2]. Driven by a market where over a billion devices are manufactured every year, the feature sets of mobile phones continue to expand enormously. Mobiles offer a multitude of ways to connect with friends, peers, and colleagues. In addition to ordinary voice conversations, mobiles can among other things be used to record and replay sound, take notes and photographs that later are shared with others or sent to a course blog or an instructor to receive feedback. The combination of social networking and mobility allows students and colleagues to collaborate from wherever they are. As innovation continues in this highly competitive market, prices for established features will drop considerably, and in only a short time span it is expected that mobile broadband with full featured Internet access will be generally available. Smaller and less expensive than a laptop, the mobile will be the ultimate device for doing many school related tasks.

The development described above provides education, learning-focused organizations as well as the game industry with a number of critical challenges and opportunities. One such challenge is to deliver services, content and media to mobile devices, reaching the students and customers wherever they may be. Another challenge is to exploit the social networking capabilities of the mobiles to create collaborative learning and collaborative experiences.

Theories on learning and learning with technology

From a theoretical perspective it is acknowledged that learning and knowing depends heavily on our use of cultural tools in social communities [3]. Students learn *with* technology rather than *from* it. The technical tools available today are very different from the technology of the sixties, which means that the situation for learning and knowing is different. Digital games, either on computers or mobile devices, are potential 'Mind Tools' [4], which may be used to enrich and deepen experiences and learning. It has been suggested that digital games as cultural tools are uniquely suited to the learning styles developed in today's youth. This does not, however, guarantee that digital games work that way in relation to a specific educational goal. Even if technology offers the potential for teaching and learning, without proper design of content and interaction with other educational material the medium can be ineffective or even damaging. Research on commercial games demonstrates that many of these seem be rather one-sided, gender biased and with low educational potential [5].

Another theory on learning, Gardner's Theory of Multiple Intelligences, explores a different aspect of learning and teaching. The basic assumption of the theory is that people employ different strategies for learning, and that these strategies relate to internal strengths and capabilities that can be classified into eight categories, which Gardner called 'intelligences' [6]. The implication of this theory is that learning will become more effective if learners are offered the chance of using the whole range of different capabilities and strategies. This is what good mobile learning environments or digital games do. They offer almost every one of the eight strategies suggested by Gardner. Learning environments and computer games that are considered 'good' provide information in various formats (visual, textual, auditory, etc.), and learners or players can choose a style that matches their own preference. Games monitor the players' actions in ways very similar to what is used in self assessment and formative assessment, which means that players are given various forms of feedback, that keep them engaged and help them learn the game and master the content [7]. The amount of support is controlled by the player. Rarely the simple 'answer' is given in return. Good environments and games thus adapt to and support various learner strategies. Concrete learners are supported by

visual, auditory, textual, progress charts and other feedback mechanisms. Abstract learners can develop theories and test them out within games in ways not feasible in real life, whereas sequential learners can progress through games in an orderly fashion. Yet for more random learners, the option also exists to choose among various 'next steps'. The linguist James Gee, has from still another point of departure, described the discursive richness, and the complexity of game play [8]. He has pointed out the opportunities of collaborative inquiry, exploration of situated identities, and complex forms of learning and participation. Researchers have argued that 'good' digital games and learning environments embody sound pedagogy [8, 9].

Representations of content and different learning modes

As discussed above one of the main advantages of ICT-based environments in general is that they support information in various formats, matching the learners own sensory modalities like visual and auditory. Mobile technology, which offers physical activities and movements as part of the learning process, has the potential to engage the learner also at a kinaesthetic and tactile level. The comparative analysis of the results from the game play sessions showed that, offered a multimodal learning environment as implemented in the MathX: The Search For Ancient Wisdom game prototype, there was an increased awareness of the learning styles among the students. There was also a shift towards auditory and kinaesthetic learning modalities. This has important consequences for developers of future mobile applications and content should, if possible, be represented in such a way that it adheres to a number of learning styles. The representation may include graphics, pictures, animations, video, audio and interaction with the environment or other artefacts through physical activity of the learner. The sensor based platform used in the tests implemented several assignments that were communicated through physical sensations, and this can be further exploited.

Another and important aspect of the multitude of representations in games or learning environments (at least for mathematics which has been the subject in focus for the MLE projects applied research) is how they provide for the ability to go between different representations. Making the student switch between different representations is a criteria for good knowledge [10]. Stated differently, the broader span of representations makes it easier to see and use analogies in problem solving, and the aquired knowledge will be more useful. The link between visualization and symbolic representations has been singled out by Klawe as being of special importance [11].

The comparative analysis revealed a number of other things related to content and how it is represented. The interface of the mobile device should be intuitive, and it should be easy to access instructions. Further, it is important that the learners remain in control of the information flow, being able to go back and forth between tasks without losing track of where they are. Solving tasks as part of a mobile game or assignment often means that data or objects representing data need to be handled or manipulated. Students emphasized that this could be done directly on the screen of the device using different tools, e.g. calculator. Studies by Klawe and co-workers, on the other hand, indicate that also simple external tools like paper and pencil are important when handling data and reasoning [11].

Collaborative learning

Theories on learning emphasize the role of collaborative learning and social communities [3]. Collaborative learning can be seen as an approach to learning in which students are working in groups, and are involved in problem solving or activities with a shared goal. Furthermore,

other researchers argue that learning is fundamentally situated, and that it can be seen as a social, active, constructive process taking place in rich contexts [12]. Just as ITC-based mobile environments support information in various formats, matching the learners own sensory modalities or intelligences, it is argued that these environments support and enhance collaborative learning. Due to the importance of collaboration and collaborative learning these aspects were focused in the design of the mobile game prototype MathX: The Search For Ancient Wisdom, which is supposed to be played in groups of three or four students dependent on the mobile platform. The collaborative aspects were also focused in the questionnaires and interviews following the game play tests. The results showed that the experiences with the game led to a more positive attitude towards collaboration, and that the majority of the students perceived themselves as fully involved in the work of the group. Field observations, however, showed that many groups were dominated by one or two learners. This difference can be attributed to the fact that some students see themselves as part of the collaboration even if they are not actually engaged in or contributing to the main problem solving task. To avoid these situations and provide equal opportunities for all learners, regardless of their prerequisites, developers of mobile applications need to take special care in the design of both content and the way it is transmitted. Involving the learner in different tangible tasks and actively scaffolding users in roles may be one way to go. An example of this is given by the sensor based platform used in the MathX: The Search For Ancient Wisdom game-play.

Collaboration occurs naturally within a group. However, the excellent communication features of mobile devices make it possible to extend collaboration to other groups in a multi player fashion. This gives new and interesting possibilities, where problems can be solved only when data or correct answers are available from a number of groups. A restriction in school settings is that the costs for data transfer etc. for the students should be minimized, and thus communication needs to be done using Bluetooth or by other means.

Games and other content

A game can, somewhat simplified, be defined as a rule based system with a varied and quantified outcome, where different outcome are assigned different values, and where the players exert themselves to impact the outcome. As discussed in the section on learning theories, games have great potential for learning if designed for their context of use, and a number of design principles are discussed by Gee [8]. In the MLE project the mobile game prototype MathX: The Search For Ancient Wisdom was evaluated and both the students and teacher anwsered to a number of questions around the narrative story and the game experience. Some students found game elements in MathX: The Search For Ancient Wisdom whereas others did just see it as a math excersise. This is not surprising, seeing that this was a prototype and not a fully developed game. From the comments of the students on desired qualities of a game there should be a tight integration between content matter and the narrative. Also there should be different levels of challange. In general the statements of the learners seems to be in accordance with the common understanding of aspects that are important for young players: engagement, interaction, challenge, ownership, accomplishment and community.

The services offered by mobile environments can be used to support learning on a more general level, not connected to games or specific applications. Several surveys among students, see for example [13,14], showed that they felt positive about using mobile phones in different educational settings, such as group work, interaction with the teacher, posting images and video sequences to the school bullentine board, receiving simple excercises

improving spelling, reading and math. A possible niche for developers of mobile learning environments would be provide services for this type of interaction and also connecting mobile phones with school systems like Fronter.

Learner generated content

Teachers have to invest time and effort to master new technology. In order to extend the scoop of mobile learning environments and their applications making them more general tools, some teachers in this study suggest that there should be a development kit so that the teachers and/or learners have the possibilities to contribute content themselves. The process of designing content, excersises or games gives the teachers and students possibilities to think about teaching and learning, and it also provided situations that naturally combine issues of practice and theory. Several studies indicate that for example game design can be a powerful learning context for both teachers and students [15].

Whereas general mobile games are difficult to make site specific, games or content designed by the teacher or students using a development kit can use the environment around the school in a creative way to enhance the feeling of committment. Combining for example, digital photos, video clips, and satellite images from Google Earth over the local environment opens up a number of possibilities that are worth exploring by developers of mobile learning environments (see also the section on future issues).

Relation to formal school structure

A problem related to strong capacities of games or well designed learning environments to absorb and engage students is that they often fail to have conscious awareness of concepts, structures and functions they encounter during the game. This may lead to a weak transfer of what they have learnt to other contexts. A number of factors can, however, be used to focus attention and improve transfer. As discussed by Klawe [11] three important factors are:

- Teacher attitudes. Teachers should make explicit statements about the reasons for playing the game and engage in various activities that integrate the playing experience with other classroom experiences.
- Supporting activities. Whole class and smaller group discussions about the game and the underlying educational content. Paper and pencil activities modelled on the game activities.
- Collaborative play. Working in pairs allows the students to recognize and articulate the concepts in the game.

The work of Klawe has been extended by Åresund and Heath in a Prepare, Play – Learn model [16]. The model, displayed in figure 1, starts with both pedagogical and practical preparations aiming at creating the best possible cirumstances for the gameplay. Also the game tools are tested. After the preparations the game play sessions are carried out. The session takes place both within, and outside of the formal school context by utilizing the capabilities of mobility in learning. The mobile learning game may provide options for extending the temporal and spatial aspects by including game content or additional content, which can be accessed by a player between play sessions. This enables the players to bridge the gap between their formal and informal learning contexts, increasing the transfer.

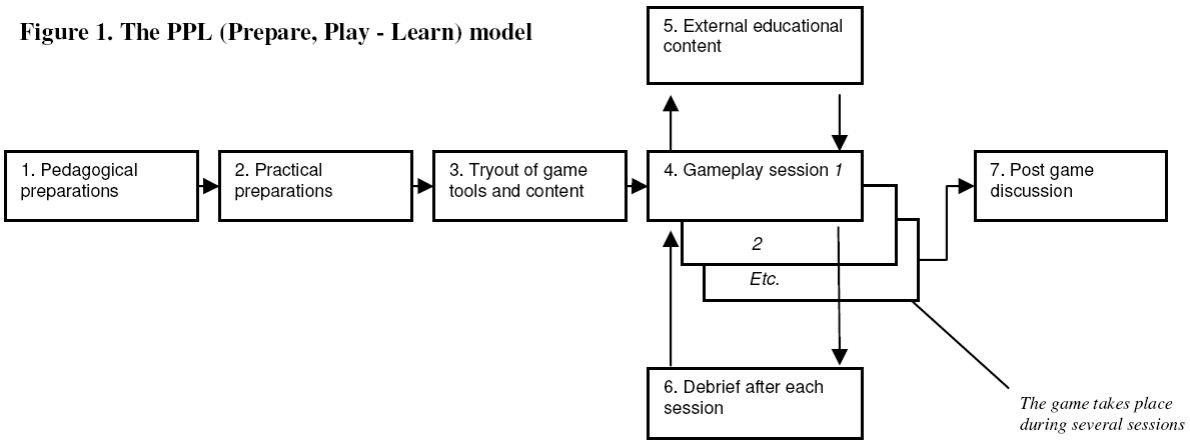

Figure 1. The PPL (Prepare, Play - Learn) model

The rationale for developers of mobile learning environments is that they must pay attention to transfer effects and how the application can be incorporated in the normal school setting. The intended use of the application or environment should not only be episodic - a fun break - but an integrated part of the curriculum and the work in the class, so that the time spent mastering the mobile environment is reflected in the potential for using it in a number of curricular activities. Providing a scheme or plan for the use of the application in school together with other educational material will also give the teacher the feeling of being in control. The latter is important and has been emphasized by a number of teachers and teacher students.

Inclusion and participation

The school system has the responsibility to provide all students with confidence, skills, and knowledge so that they can acquaint themselves with, and critically examine, various forms of quantitative and qualitative information. This is the basis for an equal and democratic society. Studies and surveys, however, show that as many as 12 % of today's students have severe difficulties in reading, writing, and handling mathematics. This student group is inhomogeneous, but some common cognitive deficiencies have been identified such as: limited working memory, phonological problems and difficulties with automatization [17]. Sterner and Lundberg discusses several pedagogical strategies, that in our view are very well supported by mobile learning environments, to help this group of students. We account for some of these strategies: complement written and spoken information visually or by action, use laboratory work to create mental conceptions, support students own ways of expression, go from concrete experience to mental representations and finally to symbols, create a link between language and action, use more senses for learning [17].

Students with different cultural backgrounds and with a limited knowledge of the official language in many cases also have difficulties. In texts related to teaching and learning, words that are not part of the student's normal language are often used. In addition the texts are compressed with a high density of facts. A misconception of a single world may lead to a complete misunderstanding of the text. A recommendation to manufactures of mobile learning environments is to complement text on the screen with sound, where the content is less compressed and with redundancies so that single words are less important. Another way is to use illustrative video clips. It could also be worth while to include a suitable dictionary

among the tools of the device.

Guidelines for developers of mobile learning environments

In this report different aspects of mobile learning environments have been discussed. Based on theories on learning and the comparative analysis of the results from the mobile game prototype test sessions, a number of qualities of such environments have been identified. For the convenience of the reader these qualities are summarized below.

The first set of qualities is connected to the presentation of the content and different learning modes. The mobile learning environment and/or application should provide for:

- Intuitive interface
- Easy access to instructions
- User control of the flow of information
- Support for direct manipulation of objects on the screen
- Illustrations and visualizations, link with symbolic representations
- Support for different learning modalities or 'intelligences'
- Physical activities
- Access to supportive tools e.g. calculator or graphing aids

The second set of qualities is related to game design and collaborative learning. The game or mobile learning environment should have:

- Robust integration between content matter, such as i.e. mathematics and game play
- Context sensitivity – gather data unique to current location, environment, and time
- Collaborative learning – providing settings for social interactions within a group and between groups
- Active scaffolding of users in roles
- Individuality to the level of the users – providing adequate challenge and support
- Tangible feedback

Finally, the third set of qualities concern integration of the learning environment in the school systems. In order to have a high penetration in schools a mobile learning environment should have:

- Clear and readable instructions for teachers
- Description or notion of how content can be integrated in ordinary teaching
- Be designed to be incorporated in the normal school setting, paying attention to transfer effects and how the applications within the mobile learning environment can provide the students with the ability to shift between representations.
- Organizing tool allowing teacher to overview student activities

- Support for teacher and learner generated content

Often small details in the content, design and presentation make huge differences in the way a product is perceived both by students and teachers. Future developers of mobile learning applications are therefore strongly advised to closely study the growing literature on mobile learning and also to consult experienced teachers to get their views.

Future issues

Mobile learning environments are developing at a pace where it is difficult to discuss future issues. Having said this we still want to emphasize the great possibilities offered by different spatial markers, e.g. RFID-tags or GPS. Placing a game or mobile application at a special location means that data unique to the location, environment, and time can be utilized. The real environment can then be spatially overlaid with a digital layer of information to create an augmented virtual reality [18]. A development kit, including a game editor, for these applications can be downloaded from the MIT STEP's Handheld Augmented Reality Simulations Site http://education.mit.edu/drupal/ar.

The current generation of mobile devices is still limited by several inhibiting factors such as: small screen size which means small font size and scrolling, non-ergonomic input, comparatively slow CPU, limited memory and non standardized operating systems. These limitations are largely overcome by the rapidly evolving Ultra-mobile PC's (UMPC's). The fact that the UMPC's are now costing less than high-end mobile phones makes these devices interesting to include and explore in relation to mobile learning in the future.

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