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Mobile Learning – Quality Standards, Requirements And Constrains

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Abstract:*Mobile devices are becoming more common tool in everyday life. There are many areas of implementation, and in this paper, the use of mobile devices in education and training (also known as m-mearning) is considered. The advantages and limitations of mobile devices and its use in education and several examples are also presented. Since this is new area, there are no generally recognised standards for its implementation. Some recommendations and technical standards on mobile content development and delivery are given.*

Keywords: *mobile learning, training, mobile device, recommendation*

1. INTRODUCTION

Mobile phones are becoming everyday necessity and now it is almost impossible to imagine how complicated our life would be without them. It is obvious that wireless communication and access to the Internet are the basis of future development of communications, one of the most profitable and most expansive parts of the technology. Because of the wider usage of wireless access to the Internet, the acronym wwww (wireless world wide web) became common in the literature.

By the development of telecommunication technology, mobile phones are, except for its primary purpose - voice communication, today used for a variety of other objectives and purposes. Everyday they are becoming more like pocket computers, because every new generation of the phones brings some new hardware and software solutions.

At the same time, the completely new areas of application are being introduced and developed, so today we could take part in various kinds of voting, pay parking, check sports results and weather forecast for tomorrow, or just read the latest news.

Two most used technologies are SMS (Short Message Service), in which the exchange of information is done by short textual messages, and WAP (Wireless Application Protocol), which refers to the design of web sites readable by mobile devices.

However, the wider use of mobile devices begun only a few years, so still there are no generally accepted standards for different aspects of this usage. In this paper, some experiences and recommendations for the implementation of education using mobile devices will be presented.

2. M-LEARNING

There are numerous definitions of mobile learning (m-learning), but we will use one by which mobile learning in every way of education or help in education, including information distribution and collection, based on mobile devices. Another, very good definition is that mobile learning is an approach in electronic learning (e-learning) that utilizes mobile devices. Although often m-learning is seen as simply an extension of e-learning, in fact quality m-learning can only be delivered with an awareness and special care of the limitations and advantages of mobile devices[1].

Under term “mobile device”, we will consider digital mobile devices such as:

- mobile phones,
- PDAs (personal digital assistants),
- personal digital media players (e.g. iPods, MP3 and MP4 players),
- smart phones (hybrids between mobile phones and PDAs, with good characteristics of both: voice communication ability of mobile phones and computer-like characteristics (processor, memory, software, etc.) of PDAs), etc.

Although laptop computers and notebooks can be also used to facilitate mobile learning, they are rarely considered as mobile devices in narrow sense, which usually have small screen and keyboard and are pocket-sized. It is expected that in the following years smart phones will be the best mobile platform for the development of mobile education and training.

The main advantages of m-learning comparing to e-learning are [2]:

- it could be performed any time and anywhere i.e. at time and place most suitable for the user. Even during short break (e.g. while waiting for the bus or train or traveling to your school or job), it is possible to connect to the system and read some modules or test acquired knowledge,
- most of mobile devices have lower prices than desktop PCs,
- smaller size and lighter weight that desktop PCs,
- higher availability i.e. much higher number of mobile devices compared to desktop PCs.

The estimation is that today there are over 2 billions of mobile phones in use (the estimation for 2004. was about 1,5 billions). As the number of PC and other types of computers is significantly lower, it is obvious potential of education based on mobile devices, because it is also obvious that in the future period the existing trend will continue, i.e. the number of mobile devices users will be much bigger that the number of computer users. In addition, this way of communication and devices is particularly popular among young population, so even in developing countries, the percentage of persons aged 16-24 that have mobile phone is over 90%.

Finland experiences [3] show that in 2002 over 70% of population and 98% of students had mobile phones. Similar situation was in Ireland [4], where 53 out of 54 interviewed students had mobile phone with WAP browser. The estimation is that every inhabitant of Hong Kong has at least one mobile phone [5].

The development of mobile devices and telecommunication technology (3G mobile telephony and wireless local area networks (WLAN) for mobile devices) provide the data transfer on much higher flow rates, so today it is possible to transfer not only textual (SMS) messages, but also multimedia contents (pictures, images, audio and video clips, files, etc.), which could be used in development of new approach in education based on mobile devices.

Mobile Web services and applications are usually developed [5] using WAP (the set of standards which enable programmers to develop web applications for mobile devices by using WML), I-MODE (Japanese equivalent to WAP) and J2ME (Java 2 Micro Edition, the software platform for the development of the applications for mobile devices).

The main limitations on wider application of mobile devices in education are [5]:

- small screen size, which means small letter size and a lot of scrolling while reading,
- small keyboard, so data entering is tiresome (some of the solutions for this problem are voice or handwriting recognition or light pen)
- slow processors, but with the latest generations of processors for mobile devices, this problem is not so important
- limited memory size (the latest phones have the possibility to expand memory size by adding memory modules and cards)
- limited battery capacity (also this problem is significantly reduced by the use of new lithium batteries or, in future, fuel cells)

- no standard software platform and operating system for mobile devices (at the moment, the dominant is Symbian OS, followed by Windows Mobile)
- data flow rate, but also this is much improved by 3G system.

Pilot applications, which enable professors to transfer their lectures, tasks, tests, etc. to the database available to the students by mobile devices, are already developed [5]. The students are able to read the tasks, do the tests, and send them to the professors for examination and to receive the answer at the end, all by using mobile phone.

The application of mobile devices in higher education is in the process of intensive research and development. European Union is very interested in this development and financially supports many projects in this area. For example, Mobile Learning project (http://learning.ericsson.net/mlearning2) was fully supported by Leonardo da Vinci program, financed by European Commission [6]. The main objective of this project was development of materials for university courses, adapted for mobile phones, as well as testing and assessment of those courses by students. This project was considering not only present but also the newest generation mobile phone, so it is not surprise that one of the main partners in this project was famous Swedish mobile phone manufacturer, company Ericsson.

E-Viva project (www.viva.tv) [7] is a research project, with the objective to explore the potential of the usage of mobile phones as a system for student testing. The system is based on conversion of student voice answer to text, by special hardware and software system.

At University of Regensburg, Germany, so called Virtual University (VUR – Virtual University of Regensburg) was developed [8]. This system has module for mobile devices, called WELCOME (Wireless E-Learning and COMmunication Environment). Services in this module are divided in four parts: study administration, mobile education, communi–cation with the colleagues and professors and services related to the life in campus. It is showed that this way of communication and learning has faster reaction, lower expenses and improved quality. The SMS module for student informing about important events and news was also developed.

Spanish National University for Distance Learning (UNED) is the biggest Spanish state university, with 10% of student population in Spain. At this university, except the usual forms of electronic education, in the year 2001 WAP services were developed [9], with different information about the University and study programs, available to students. In addition, it is enabled to professors to leave different messages and suggestions to the students, using mobile phones and SMS services. New services are developing continuously.

At Kingston University, Great Britain [10], [11], [12], the research of effectiveness and efficiency on bi-directional SMS campaign was performed. The system that enables sending of SMS messages with dates and times of lectures and exams (schedules), changes in those dates/times, marks, etc. to the students was developed. Students-participants in the research were divided in three groups: the first one was notified by e-mail, second one by SMS messages and the third one by Internet i.e. on University web page. The conclusion was that the vast majority of students has chosen the SMS messages as the best way of notification.

Similar system was developed on Faculty of Economics, University of Kragujevac [13], [14]. This system enables bi-directional communication with students via SMS messages. The first version enabled only sending messages with various information to the students (marks on the exams, schedules, news, etc.), but new one is bi-directional, so now it’s possible for student to send a demand for a certain information and to receive the answer by SMS. In addition, it could be used for self-testing of the students, i.e. receiving questions and sending answers and then receiving the information if this true or not.

Learning in Virtual Environment), University of Sheffield, etc. One of the most common use of m-learning is for learning of foreign languages [12], [15]. For example, during Olympic games u Athens in 2004, tourists were, after registration, receiving every day short lectures of Greek language by SMS messages [16], [17].Except for higher education, m-learning has a very interesting potential for education and training of already employed. The expectations are that life-long learning will be one of the mayor target groups for m-learning in the future.

3. TRAINING MODEL

Since mobile education and training is a very young discipline, there are no generally recognized standards in this area. Usually, it's possible to use general standards and standards for e-learning, adopted to m-learning, i.e. respecting all advantages and limitations of mobile devices.

Related to the training model, the most appropriate model would be one given in ISO 10015:1999 standard – *Quality Management – Guidelines for Training* [18]. The quality management principles underlying the ISO 10000 family of standards (those standards are the part of ISO 9000 series) emphasize the importance of human resource management and the need of appropriate training of personnel i.e. personnel at all levels should be trained to meet organization's commitment to supply products or services of a required quality in a rapidly changing market place where customer requirements and expectations are increasing continuously. The aforementioned Standard provides guidelines to assist organizations and their personnel when addressing issues related to training. In may be applied whenever guidance is required to interpret references to "education" and "training" within the ISO 9000 family of quality assurance and quality management standards.

According to ISO 10015:1999 training model could be presented as a six-phase process with the following phases [18]:

1) Analysis of problem performance,
2) Definition of training needs,
3) Design and plan of training,
4) Provision for the training,
5) Evaluation training outcomes,
6) Monitoring and improvement,

given on Figure 1.

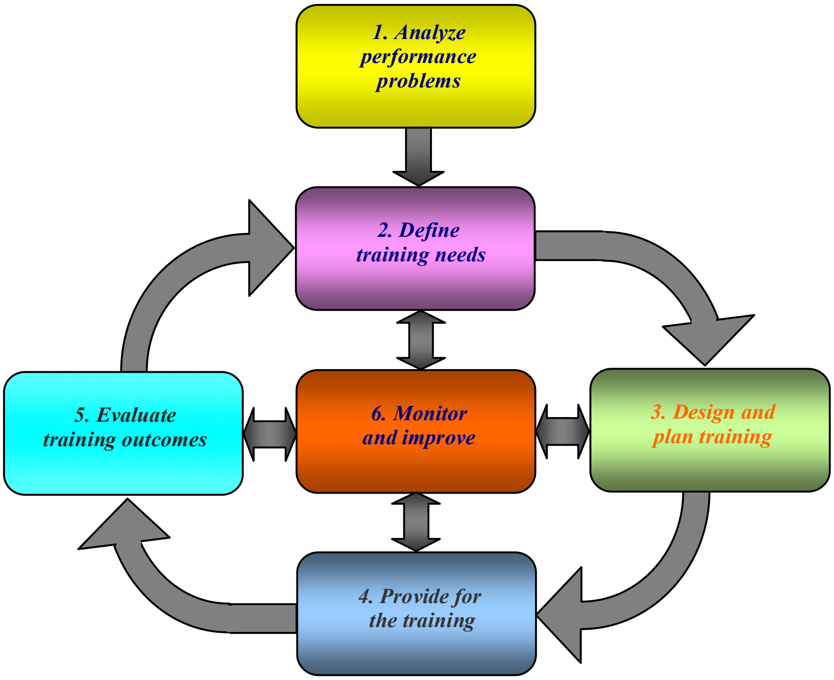

Figure 1. Six phase training cycle

4. TECHNICAL STANDARDS AND RECOMMENDATIONS

As stated previously, there are no internationally recognized (ISO) standards for the use of mobile devices in education and training. In this paper, some technical recommendations given in "*M-learning* *standards report*" [19] by Australian Flexible Learning Framework will be presented. Flexible Learning Framework is a group of experts, supported by Australian government and Ministry of Education, Science and Training and they give many recommenda–tions and standards on the application of different novel technologies in education.

Standards can be defined as "documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose" (ISO, 2002) [20].

Many (but not all) issues and best practices for the implementation of m-learning may be derived from parallels with the development of computer-based training (e-learning) a decade ago.

The display resolutions, storage memory and processor capabilities and conflict of hardware and software platforms and standards during early-to mid 1990s are roughly analogous to current state of mobile devices and technologies [19].

Remote access to data from mobile devices is limited by both technical and economic constrains. In technical terms, the speed at which mobile devices can access data wirelessly in well below the speeds achievable using cabled network connections. Economically, the cost of wireless data connectivity can be very high.

This means that content prepared for wireless delivery needs to be smaller in size than the content prepared for local loading or wired network, with the implications of reduced quality.

In addition, mobile learning content is not just delivered on, but may also be created using mobile devices (e.g. by camera or sound recorder). Although there are some formats that are well established as de-facto standards (e.g. almost all photo-capable mobile devices save images in the JPG format), mobile devices rarely provide user with many options on how content is formatted [19].

4.1 Mobile audio

Mobile audio is identified as the most commonly currently utilized medium for the delivery of m-learning. To store natural audio, the original analogue sound must be sampled into a digital form. The more samples, the more detailed and accurate the digital copy. The resolution of digital audio is measured in bit depth, sample rate and channels (e.g. 16-bit, 44.1 kHz, Stereo).

The bit depth governs the accuracy of the sample and is analogous with the colour depth of a video display, 16-bit digital audio translates to 65536 different values.

The sampling rate is usually measured in kilohertz (KHz), and governs the maximum sound frequency, or pitch, that the digital audio can contain. The sample rate must be at least double the frequency of the range of sound to be reproduced, so to reproduce the full range of human hearing (20Hz – 20KHz), a sampling rate of at least 44.1 KHz is required.

The last component of audio resolution is the number of channels. A stereo sound contains two distinct channels, each one carrying different information to reproduce a distinct sound; a 5.1 audio stream contains six audio channels altogether.

The greater the number of channels, the more information required to reproduce a sound and the larger the file. A speech file may only require one channel (mono) to accurately record or convey informational content.

Uncompressed sound files take up a lot of data storage space. To reduce the size of a sound file, digital audio is usually compressed, particularly for mobile uses. The most common method of specifying how much a sound file is compressed is by specifying the 'bit rate' of the compressed file (e.g. 96 kbps). A higher bit-rate will improve the sound quality, but will increase the size of the audio file.

The most common natural audio formats in mobile devices are MPEG-1 Audio Layer 3 (MP3, widely implemented, suitable for sound and speech), Windows Media Audio (WMA, quality to weight ratio better that MP3), WAV, Advanced Audio Codec (AAC, very good quality to weight ratio), and Adaptive Multi- Rate (AMR, very good only for the recording of human voice).

The choice of the sound digitalization and compression depends on the type of sound, and in Table 1, the recommended audio specifications for wireless/streaming access are given:

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Table 1. Recommended audio specifications for wireless/streaming access

	Recommendation
Music/sound	LC-AAC or MP3 32-96kbps 44.1kHz, Stereo
Speech	LC-AAC 8-32 kbps 44.1kHz, Mono

4.2 Mobile video

Digital video generally consists of two major elements: a digital video track, with a synchronized, accompanying digital audio track. The various data streams are multiplexed together to present all of the content in a single file.

The resolution of the video screen is determined by its visual resolution – the number of pixels that are used to render each frame, measured as width x height; and its temporal resolution – how many frames are displayed each second (fps). The greater the visual resolution, the more detailed the picture; the greater the temporal resolution, the smoother the motion in the video.

Twenty-four (24) fps is the minimum frame-rate required to produce motion that appears perfectly fluid to the human eye. Each data stream within a video file can be independently compressed, such that the amount of compression of the visual stream may be different to that used for the audio stream. The separate data streams are usually multiplexed into a single file by embedding them in what is known as a container file. Examples of container file formats include Audio Video Interleave (AVI), MPEG and MPEG-4.

In Table 2, the recommended optimal video specifications for wireless/streaming access are given [19].

Table 2. Recommended video specifications for wireless/streaming access

	Recommendation
Optimal video	H.263 Baseline/MPEG-4 Part 2 (if targeting .3gp container) XviD MPEG-4 Visual Simple, Mod Level 2-3 (for MP4/M4V/AVI containers)
Video resolution	176x144 – 320x240
Frame rate (fps)	20-25. Frame rate for mobile devices should never exceed 30 fps.
Bit rate (kbps)	140-300
Optimal audio	LC-AAC
Channels	2 (Stereo)
Sample rate (KHz)	44.1 / 48
Bit rate (kbps)	96
Container	MP4 (M4V) for iPods, Sony mobiles/PSPs, and other mobiles 3GP for mobiles, PDAs AVI for PDAs

Two main "in-progress" publications of the MWI directly advise aspects of standards and best practices in m-learning development:

- **Mobile Web Best Practices 1.0** [21], elevated to the status of W3C Recommendation on 29 July 2008, which specifies standards and best practices for delivery of mobile web-based content,
- **W3C mobileOK Basic Tests 1.0** [22].

According to the draft document, *"mobileOK defines machine-readable content labels which may be applied to content to indicate that the content and its delivery pass a suite of tests based on the Mobile Web Best Practices document"*.

The following baseline recommendations are based on W3C's 'Default Delivery Context' for mobile web devices [21]:

Table 3. Recommendations for web content

	Recommendation
Text and format web pages	
Web text	XHTML 1.0 Basic Profile WML 1.0
Character encoding	UTF-8
Format web pages	External CSS Level 1
Colours	256 colour, Web Safe palette
Maximum total page weight	20 kilobytes 10 kb is a 'usable' page weight
Transfer protocol	HTTP/1.0 or HTTP/1.1
Embed images in web pages	
Images (photos)	JPEG, non-progressive
Images (graphic)	GIF 89a, 256 colour web-safe palette, non-interlaced, non-transparent, non-animated
Layout	
Usable screen width	Phones: 120 px – 320 px PDAs: 240 px – 640 px

4.3 Documents and interactive media

Creation of the documents for viewing on mobile devices should consider the limitations of mobile devices, particularly in terms of screen size. Almost all PDAs and smartphones have the ability to view documents created in Microsoft Word and the ability to view Word documents is increasingly common in mobile phones.

Furthermore, almost all PDAs and smartphones have the ability to read Adobe PDF documents, either natively or through the installation of free software. However, PDF documents that have been created using an optical scanning, non-OCR (Optical Character Recognition) process may be stored as, effectively, large image files. PDFs for mobile delivery should therefore be created from an electronic source as tagged text.

Flash Lite was originally developed by Macromedia (now Adobe) in 2003 to run Flash based rich content on the latest generation of mobile devices. A 2004-2005 study of mobile phone capabilities found that some 85% of mobile phones planned for release during the second half of 2004 onwards would be capable of using Java 2.0 Mobile Edition (J2ME) applications.

In table 4, the recommendations for document publication and interactive media are given:

Table 4. Recommendations for document publication and interactive media

	Recommendation
E-books/formatted data for read-only display	Adobe PDF Tagged text Embedded fonts
Formatted data for user manipulation	Microsoft Word (DOC) Standard fonts only
Web/embedded interactive content	Flash Lite 1.2/2.0, Frame Rate <=12fps
Stand-alone application devel. for mobile devices	Java 2 Mobile Edition (J2ME)

4.4 Wireless data connectivity

Due to the considerably higher current market penetration of 2G (GSM GPRS/EDGE) data connectivity in mobile phones, it is recommended that content intended for mobile web delivery be primarily tested for compatibility with 2G mobile devices.

The different contexts for use of Bluetooth and Wi-Fi connections advises the recommendation of separate standards for each to match their appropriate deployment contexts, as provided in Table 5

Table 5. Recommendations for the wireless data connectivity

	Recommendation
Mobile phone data interaction/delivery	Test accessibility and download speeds on 2G GPRS mobile phone
Device-to-device interaction/delivery	Bluetooth - Class 2, Version 1.2 and 2.0
Testing for wireless interaction/delivery	Wi-Fi/WLAN – 802.11b, 802.11g

In the near future, it's expected that 3G will become standard in mobile telephony.

3G refers to the 'third generation' of mobile phone connectivity, whose primary advantage is wider data bandwidth and correspondingly higher wireless data access speeds.

The number of 3G phones in use currently too low to recommend its incorporation as a standard for wireless mobile data delivery at this time.

Further advances in mobile telephony are seeing the emergence of fourth-generation (4G) standards, capable of data connection speeds near to the wired network speed (100 Mb while moving, and 1Gb when stationary).

The 802.11n standard is in the final stages of ratification, and it will enable wireless communications at data rates of 200Mb/s (typical) up to a maximum of 540Mb/s.

5. CONCLUSION

The application of mobile devices in education and training is new, but very perspective area. Mobile devices still have some limitations, but many problems are solved or minimized. Several international projects and conferences are dealing with m-learning and many applications already exist.

There are still no internationally recognized standards, but there are very good recommendations (which could soon become standards) for m-learning. Some of them, for the mobile web development and delivery, were presented in this paper.

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