Multimedia Applications and Technologies for m-Learning

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We live in a very dynamic environment where an efficient time management has a very important role in becoming successful. An efficient time management may mean minimizing the idle time and also doing the right things at the right time. Mobile devices have become one of the most used items in our daily activities. Kids using portable gaming devices, teens using portable media players and cell phones, adult professionals organizing their calendar and exchanging emails using their mobile phones, and others who wouldn't probably leave their homes without grabbing their cell, just in case that an emergency arises or they receive an important call. Mobile devices development is progressing at a very high pace and now we can hold in our palm a device that has more computing power than the bulky computers of the late 90's. In this article we will present how minimizing the idle time of individuals can be achieved using mobile devices and also how mobile devices allow individuals to access the information they need when they need it. The article lists the benefits of learning using mobile devices, describes the cognitive principles of multimedia, the means to deliver multimedia content that respects those principles, hardware requirements and limitations of the current mobile devices and presents the trends in using these devices.
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1 Introduction

Mobile learning is a type of technology supported learning using mobile devices. Mobile learning's core philosophy is learning anytime, anywhere.

Mobile learning has the following benefits:

- It offers "just-in-time" learning;
- It is efficient for professionals;
- It can be entertaining for young students;
- It allows online connectivity and sharing;
- It allows someone to learn at its own pace;
- It is cost efficient;
- It allows someone constantly updating its skills.

"Just-in-time" learning allows students to access the information that they need, when they need it, where they need it. "Just-in-time" learning eliminates the waste of learning time by offering the information that is needed and not the information that may be needed sometime in the future, eliminating the excess accumulation of information. It also increases learning turnover rate by using the information immediately after it was learned.

Mobile learning is efficient for professionals. With increasing commuting time, professionals can take advantage of the waiting times, in the airports, train stations or bus terminals, and also of the actual travel duration, to update and improve their skills.

Mobile learning can be entertaining for young students. With the increased features of mobile devices, these devices have become very appealing to the youth. Mobile learning takes advantage of the popularity of these devices between youth and with an entertaining multimedia content, it transforms young students' learning from something that they need to do, into something that they like to do. One example of entertaining multimedia content for youth audience would be combining gaming and learning.

Mobile learning allows online connectivity and sharing between users. The 3G mobile communication standard allows download speed of up to 14.4 Mbit/s [1]. The increase of 3G networks coverage area for mobile devices allows internet connectivity virtually everywhere in developed cities. Mobile learning takes advantage of the online connectivity enabling users to access online content and not only the local content stored on the mobile device. Online connectivity also allows users to share information, ask questions, share progress

or transmit results.

Mobile learning allows someone to learn at its own pace. While regular classes have a predefined duration and usually have predefined starting time, mobile learning classes allow students to learn at their own pace speeding up the learning process if they are already familiar with the content or taking more time to understand when they feel they need to.

Mobile learning is cost efficient. Mobile learning can be 5 to 10 times cheaper than regular classes [2]. Mobile learning doesn't require physical attendance therefore travel and lodging costs are eliminated.

Mobile learning allows constantly updating skills. While regular classes can quickly become obsolete, mobile learning content can be constantly updated and, because it allows access to information when is needed it, it enables students to constantly be up to date.

2 Multimedia Principles for mobile learning

Multimedia integrates multiple media elements like images, audio, video, text, animation, etc. to provide more benefits for the end user than any of the media elements can provide individually.

Multimedia applications like animations, simulations and games are generating further learning possibilities. E.g. it is always safer and cost efficient to practice flight simulations in a virtual environment before experiencing it in the real life. Multimedia has the benefit that it can be adapted to different learning styles and preferences.

Table 1. Cognitive Principles of Multimedia [3]

Principle	**Definition**
Multimedia principle	Individuals learn, retain, and transfer information better when the instructional environment involves words and pictures, rather than words or pictures alone.
Modality principle	Individuals learn, retain, and transfer information better when the instructional environment involves auditory narration and animation, rather than on-screen text and animation.
Redundancy principle	Individuals learn, retain, and transfer information better when the instructional environment involves narration and animation, rather than on-screen text, narration, and animation.
Coherence principle	Individuals learn, retain, and transfer information better when the instructional environment is free of extraneous words, pictures, or sounds.
Signaling principle	Individuals learn and transfer information better when the instructional environment involves cues that guide an individual's attention and processing during a multimedia presentation.
Contiguity principle	Individuals learn, retain, and transfer information better in an instructional environment where words or narration and pictures or animation are presented simultaneously in time and space.
Segmentation principle	Individuals learn and transfer information better in an instructional environment where individuals experience concurrent narration and animation in short, user-controlled segments, rather than as a longer continuous presentation.

Mobile learning uses multimedia to deliver:

- The best presentation method based on the

type of content that is being delivered, e.g. if the student learns a new word, beside a definition of the word and an example of how it is used in a sentence, a picture describing the word and an audio file with the pronunciation of the word adds value to the learning process;

- The best presentation method based on the learning environment, e.g. a text book can be replaced with an audio book while the learner is driving.
- The best presentation method based on the audience, e.g. a textual description makes more sense if the audience of the class has hearing disability, but and audio description may make sense if the learner doesn't know how to read.

When creating multimedia mobile learning applications, developers should consider the principles defined in Table 1.

The principles defined above provide an initial framework for creating multimedia instructional applications that are empirically and theoretically well grounded [3].

3 Multimedia content players

Mobile applications have been developed to allow delivery of multimedia content. Such applications include:

- Mobile internet browsers
- Flash players
- Mobile media players
- Live streaming players

Some of the mobile internet browsers are vendor specific: like Apple's Safari or the web browser for Google Android. There are also non-vendor specific internet browsers the most popular ones include: Pocket Internet Explorer, Opera Mobile, Opera Mini, Skyfire and Iris.

Skyfire is a free, downloadable mobile browser that gives you a Web browsing experience exactly like PC browsing. Some of the Skyfire's highlights are:

- It plays any video. It supports full flash, supports full Flash and Windows Media videos, including Flash 10 and Silverlight 2.0.
- It allows browsing any page. It supports all major Web 2.0 standards – Ajax, Javascript, Flash 10.
- Support for popular social networking sites like: Facebook and Twitter. [12]

iPhone Safari features include:

- Browse web pages as they were designed to be seen in computer-based browsers.
- Zoom in and out
- Switch to wide view
- Built in search using Google and Yahoo!
- Email, phone number, and address links open Mail, Phone, or Maps on iPhone
- Play supported multimedia files
- Open multiple pages at the same time [9]

The **Microsoft® Pocket Internet Explorer** is a full-featured Internet browser, optimized for devices with small, vertically oriented displays and for cached or customized content. HTML functionality is equivalent to that of Microsoft Internet Explorer version 3.2, with support for tables, forms, and frames. A fit-to-screen option dynamically resizes Web pages to maximize viewing on handheld devices without requiring the user to scroll across a page. A Zoom menu option allows the user to view text on the screen in different sizes.

Automatic state-detection determines whether the device is connected to the Internet and, if not, diverts the browser to a cached version of the Web page. On Microsoft® Windows® CE .NET-based devices that include Microsoft ActiveSync®, users can update their cached Web pages automatically by designating a Web page displayed on their desktop machine as a Mobile Favorite. Then, whenever the mobile device is synchronized to the desktop machine, the current version of that page is downloaded to Pocket Internet Explorer. [10]

Opera Mini is a full web browser that:

- Adds support for skins selections to personalize the look and feel of the browser
- Has search within a webpage support
- Allows to add notes for browsed web pages
- Depending on the mobile device, has support for video
- Has auto-complete support for web addresses
- Allows to upload and download files within the web browser
- Allows to save pages for later offline access
- Allows to view pages in landscape mode

- Allows to open multiple pages in different tabs
- Allows zooming in and out. [11]

Opera Mini is implemented as a Java ME application (MIDlet) and needs a MIDlet manager like Esmertec JBed or Intent Java MIDlet Manager.

Opera Mobile is a platform dependent browser and has at least the same capabilities as Opera Mini.

Fig. 1 Opera Mobile Browser on a Windows Mobile Device

Figure 1 shows the Opera Mobile browser running on a Windows Mobile device.

The Iris Browser is an advanced, high-performance and versatile application that is specifically designed to function in resource-constrained environments. It brings the full Web experience to mobile phones, set-top boxes, mobile Internet devices, portable media players, Ultra-Mobile PCs and other embedded devices - in a fast and user-friendly manner.

Some core features include:

- WebKit rendering engine
- Customizable interface
- Touch screen control
- Advanced HTML and CSS Support
- Zoom and tap function
- Multiple windows and tabs
- Multiple input methods like handwriting recognition, on screen keyboard, iTap and auto -complete
- Software mouse cursor
- Landscape mode
- Advanced security features including phishing and spoofing protection
- Pop-up blockers [13]

There are various multimedia content players providers for also Flash payers (Adobe), streaming players (pvPlayer, HTC's Streaming Media), and mobile media players (Windows Media Player, CorePlayer).

4 Hardware Limitations

Today, there are many mobile devices used in the world, like PDAs, mobile phones, communicators, smart phones and pagers. Those mobile devices are characterized by: limited computational power, limited memory (RAM and ROM), low data input speed, small displays, battery life, limited user interface, reduced dimensions and reduced bandwidth.

Multimedia-based mobile applications require high processing power and memory. The processing power is increasing and the support for multimedia hardware acceleration is integrated on chips by microprocessors developers (Qualcomm, Marvel, Texas Instruments, Samsung, etc.).

Also, the memory capacity is increasing as new devices are developed. Multimedia applications are memory intensive applications and the memory capacity and the speed are important for the applications performance. The memory is seen in terms of RAM, video and storage.

One of the biggest issues related to multimedia applications is the display's size that allows showing small pieces of data. Thus, the user interface for these devices has to be designed so that graphical elements fit in the display, keep the information together and is not getting the user out of the context. The displays size and resolutions tend to increase (VGA, WVGA), leading to better user experience.

More processing power leads to less battery duration so here it must be a compromise between them.

The reduced dimensions involve difficulties in interaction with the device and the user interface. Smartphones tend to have bigger screens, less hardware buttons and having touch screen interface, finger-controlled.

The connectivity is based on different technologies that have various bandwidths and availabilities due user's mobility. The connectivity is very important for multimedia applications when media streaming is used.

Table 2. Common mobile devices characteristics

Characteristic / Device	Screen size	Proc. power	Memory (RAM/Flash/ Storage)	Connectivity	Input methods
Mobile phone	1"-2.5"	Minimal	1-32 MB/xSD, MMC	WAP, GPRS, EDGE, UMTS, Bluetooth, IrDA	Numeric keypad, QWERTY keyboard and touch screen
Smart phone	2.5"-4", 160x160, QVGA, VGA, WVGA	144-620 MHz	32-128/128-512 MB/xSD, MMC	WAP, GPRS, EDGE, UMTS, WiFi (802.11b/g), Bluetooth, IrDA	
PDA	2.5"-4", 160x160 QVGA, VGA, WGVA	126 MHz - 1Ghz	16-128 MB/128-256 MB, xSD, CFII	WiFi (802.11b/g), Bluetooth, IrDA	

These characteristics influence the way of designing, implementing and testing the mobile learning applications. The limitations of mobile devices in terms of memory, display, storage, bandwidth leads to less functionalities than for desktop devices.

5 Mobile Operating Systems Multimedia Features

Almost all mobile operating systems have support for multimedia applications development. Some technologies and libraries exist in desktop versions (like Open GL, DirectX etc.), other are specific to some operating system.

Multimedia m-applications (figure 2) access audio, graphics and media API through operating system or third party libraries. These API communicate with multimedia related hardware through device drivers.

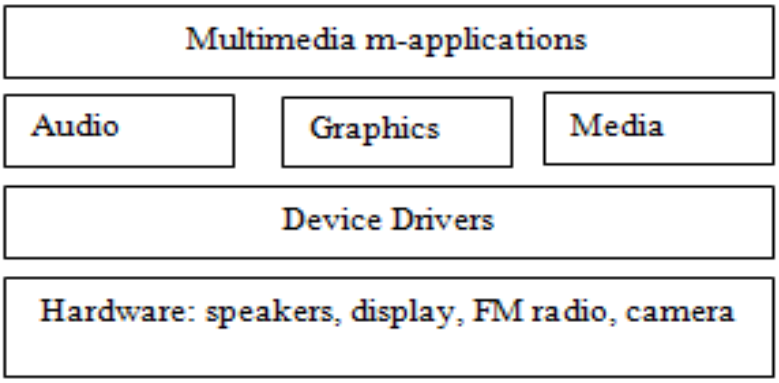

Fig. 2 Multimedia system [15]

Java Micro Edition (Java ME) is a platform implemented on almost every mobile operating system. It has multimedia capabilities through packages included in profiles (e.g. MIDP for

CLDC) or through optional packages [4]. Optional packages implementation depends on OEM. Here are some Java Specification Requests (JSRs) dedicated to multimedia for Java ME:

- *Mobile Media API (MMAPI)* (JSR-135);
- *Mobile 3D Graphics API (M3G)* (JSR-184);
- *Advanced Multimedia Supplements* (JSR-234);
- *Scalable 2D Vector Graphics API (SVGAPI)* (JSR-226);
- *Java bindings for OpenGL(R) ES API* (JSR-239). Open GL ES is the mobile version of OpenGL for 2D/3D drawing.

Many OEMs have dedicated APIs for multimedia over Java ME.

Windows Mobile, based on *Windows CE* operating system, share an important part of Win32 API, including support for multimedia applications. Some features were removed due to hardware limitations (CPU, memory etc.). Also, Windows Mobile operating system adds specific API. Multimedia support is provided (but not limited) by the following technologies [6]:

- *Graphics Device Interface (GDI)*, for basic 2D graphics;
- *DirectDraw* – support for hardware accelerate 2D graphics;
- *Direct3D Mobile*– support for hardware accelerate 3D graphics; this is can be used as COM interfaces or managed classes in .NET CF
- *Game API* (*GAPI*) – still used for graphics and input;
- *DirectShow* – media (audio and video) playback and capture support; available only as COM interfaces;
- *Waveform API, Camera API.*

Also, third party API, like Open GL ES, can be used for 3D graphics and other multimedia features.

Symbian OS, who powers more than half of the worldwide smartphones, has the following capabilities in terms of multimedia support for applications [5]:

- audio and video recording/playback (*Multimedia Framework – MMF* and *Media Device Framework – MDF*);
- still image conversion (*Image Conversion Library – ICL*);
- camera control (*Onboard Camera API – Ecam*);
- FM radio receiver support (*Tuner*);
- Bi-dimensional graphics using GDI-like classes; it provides graphics primitives for shapes and text drawing.

Apple's iPhone OS has gained popularity since first version launch in 2007, especially by multimedia experience. It provides multimedia support for [7]:

- 2D and 3D graphics:
  - *UIKit* – user interface controls and 2D drawing and user interface animation;
  - *Core Graphics* (*Quartz 2D* engine) – drawing vector graphics, bitmap images, and PDF content;
  - *Core Animation* – motion and dynamic feedback for the user interface;
  - *OpenGL ES.*
- Audio and video: *Core Audio*, *OpenAL*, *Media Player*

Relative recently launched, *Android* operating system has an increasing market share. Applications developed for Android are written in Java and are different by Java ME. Multimedia is supported by Android [8] through:

- 2D graphics and animated shapes using custom classes;
- 3D graphics using *OpenGL ES 1.0*;
- Audio playback and recording (*MediaPlayer* and *MediaRecorder* classes)
- Video playback (*MediaPlayer* class).

The audio and video playback and recording depends on the installed codecs and decoders on the mobile device.

Using operating system native API leads to faster applications but long development curves and difficulties on porting applications to other operating systems.

The development of multimedia m-learning applications has to take into account all the existing technologies and to choose the best combination in order to cover a large number of mobile platforms. Some technologies are requires more resources and can be used only on high level devices, that are not available for everyone in the learning process that involves the use of mobile devices.

6 Conclusions and Future Work

Even with the current hardware and software limitations, mobile devices are still supporting complex multimedia based applications. Currently, compared with desktop applications, mobile applications, especially multimedia-based applications, have serious limitations due the processing power and memory constraints.

There is support for multimedia m-applications, but the portability is an issue among various mobile operating systems running on various mobile devices. This issue can be solved by standardizing the frameworks and trying to implement common APIs and technologies on mobile operating systems.

Nevertheless these limitations are not taking away any of the benefits of mobile learning, mobile devices industry is progressing at a very fast pace, current limitations will be overcome and multimedia mobile learning applications will be enhanced even further.

The development of mobile devices that now have high resolution built-in cameras with video streaming support and high speed internet has enabled the option to broadcast live video. This option allows students to share the contents of class they are attending with their colleagues which for some reason couldn't make it to the classroom. In this case there is no need for any additional hardware, just take out the cell phone that almost every student carries with him, enables the camera and start broadcasting. The unlucky colleague that couldn't make it to the classroom just needs to access the broadcast using a browser either on his PC or on his mobile devices.

For some people, mobile devices are not only part of their daily life but they are becoming the tool to broadcast their life. A new trend has started that is called "lifecasting" [14] where people are using their mobile devices to stream their life online. This is done via social networking websites that allow you to share with your friends and family snapshots and live events from your daily life.

Several metrics related to multimedia-based mobile learning applications will be developed. These metrics take into account the m-learning applications requirements and education fields, the hardware and software capabilities of mobile devices and other characteristics in order to develop better m-learning applications.

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