Software Characteristics of M-Learning Applications

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Abstract: The exponential growth of mobile technology in recent years, increasing availability of network infrastructures, advances in wireless technologies and popularity of handheld devices, have opened up new accessibility opportunities for education. In his research Kinshuk (2003), [2], concludes that the true potential of e-learning as "anytime and anywhere" has finally started to be realized with the advent of mobile learning, m-learning. The paper analyses the impact of m-learning and describes software characteristics of this type of application.

Key-Words: quality, software, m-learning, characteristic, mobile devices, mobile technologies.

1. Introduction

This paper discusses whether the ability to use information and produce new information through mobile technologies (mobile learning) are a significant part of the lives and learns of most students today. Also, the paper analyses the quality of this type of software application.
A mobile device is a single integrated point of communication and useful access to information (data), applications and users/students (figure 1). Through the mobile device data transfer become easily.

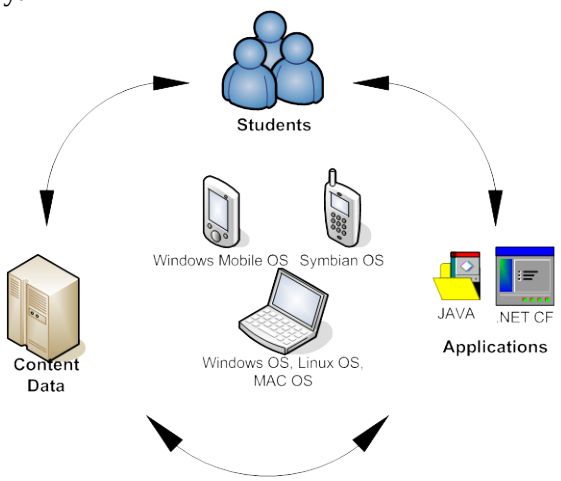

Fig.1 Mobile device integrated point

A common trend in mobile age is the distribution of large quantities of data through a mobile interface. This can be made easier to a mobile device, which grants users access to multiple information. Mobile devices are becoming the preferred way of providing centralized access to dynamic content from multiple, disparate sources.

2. Support of mobile learning

Mobile learning is significant because it's a quickly growing trend, in US demand for m-learning products and services is growing at a five-year compound annual growth rate of 21.7%, [1]. Compared to just a few years ago, mobile learning devices are become a solution of easy student-computer interaction. In this model information processing has been thoroughly integrated into everyday objects and activities of students.
There are four main reasons that could be invoked in support of mobile learning:

- Flexible

Firstly, learning can take place anytime, anywhere. Learning can happens across locations, or mobile learning takes advantage of learning opportunities offered by portable technologies. Students are overtime in go, so they are interested by more flexible kind of learning.

- Collaboration

Secondly, through mobile learning everyone uses the same content, which will in turn also lead to receiving instant feedback and tips. This learning will reduce cultural and communication barriers between faculty and students by using communication channels that students like.

- Motivation

Thirdly, multimedia resources can make learning fun. With this kind of learning, it is much easier to combine gaming and learning for a more effective and entertaining experience. This is a great point of view

because most of students are learn more when they are do something just in play.

- Accessible

Fourthly, mobile is accessible virtually from anywhere which provides access to all the different learning materials available.

- Portability

Moreover, the small size and weight of mobile devices means they can be taken to different sites or moved around within a site.

Mobile technology can effectively support a wide range of activities for students. It provides for each student to have a personal interaction with the technology in an authentic and appropriate context of use.

3. Significant challenges of learning

On the other hand for these implementations of m-learning in University to be successful, teachers and technology developers must to have in view significant challenges:

- **Mobility:** the ability to link to activities in the outside world also provides students with the capability to 'escape' the classroom and engage in activities that do not correspond with either the teacher's agenda or the curriculum. The 'anytime, anywhere' capabilities of mobile devices encourage learning experiences outside of a teacher-managed classroom environment. Both scenarios present significant challenges to conventional teaching practices.
- **Informality:** students may abandon their use of certain technologies if they perceive their social networks to be under attack. The benefits of the informality of mobile devices may be lost if their use becomes widespread throughout formal education.
- **Ownership:** students want to own and control their personal mobile devices, but this presents a challenge when they bring it in to the classroom, [2]. For example, a group of researchers decided in [3] to offer mobile devices for students, 150 students, to see if they use them for other things at home, but not for learning. Most of them use mobile devices for the things they enjoy most, instant messaging and downloading music, a few of them accessing internet pornography at home and two students hacking into teachers' computers. Only a few use mobile devices for improve their knowledge. The results prove that ownership of mobile devices does, however, present a challenge to conventional teaching practices.

Mobile devices can enable students to learn by exploring their world, in continual communication with and through technology. Instant messaging, for example, enables students to create learning communities and exchanged anywhere in the world their ideas.

4. M-Learning projects typologies

The m-learning application is not a fully knew concept because it is defined around an e-learning entity. The last one has been developed and used since the implementation at large scale of computer networks, since the appearance of Internet. The m-learning architecture extends the e-learning process taking into account users' mobility and the technologies that allow them to stay connected with electronic learning services.

From the entities viewpoint, the m-learning architecture, described in figure 2, is defined by:

- M-learning service provider represents the entity that offers the electronic learning services; its role is to manage content, users and to provide access services; in [10] it is described a generic architecture that make usage of an existing Learning Management System and extends its components to allow deployment of e-learning and m-learning applications; this architecture may present specific particularities depending on supported services and technologies; the analysis of an actual m-learning architecture will become the subject of future work on this topic because it requires a real m-learning system.
- Mobile services provider that offer mobile voice communication also provide data transfer services based on their infrastructure; some services like SMS and IVR are implemented on this side accordingly to the m-learning provider requirements; between these two entities communication is implemented by services provided by the mobile carrier;
- User and its mobile devices that allows him to get access to the m-learning resources; the main categories of mobile devices used in this architecture are Personal Device Assistants (PDA), Smart Phones, Cell Phones, Tablet PC and Notebooks; each of them has distinct characteristics that allows or limit the use of various applications and services; depending on their operating system, data transfer capabilities, processing power, memory, display and input peripherals the m-learning provider must develop applications and services that will run in optimal

conditions and that will respond to the device limits.

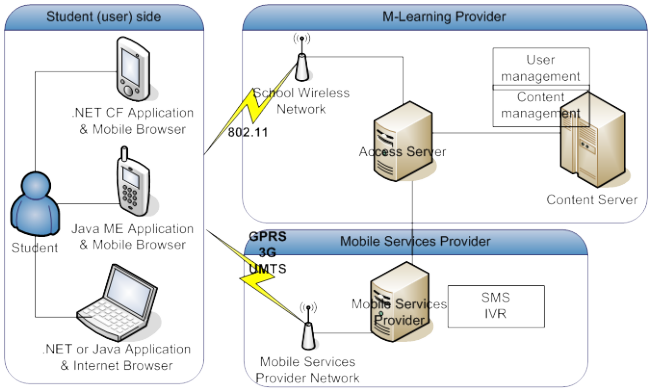

Fig. 2 Entity architecture of an m-learning process.

Inside the student area, devices communicate between them and with the system using:

- BlueTooth technologies that allow communication between mobile devices, data transfer and access to different resources like shared printers and other Bluetooth compatible devices;
- InfraRed data transfer between mobile devices that incorporates an IR port;
- USB cable to connect and to transfer data between mobile devices and a local computer; it also allows the synchronization of various applications like email clients or agenda management applications that run both on the personal computer and the mobile device.

The student mobile device will communicate with the m-learning system using:

- Wireless networks that are implemented by the university or school; the price of this technology is very low and it allows implementing wide areas of coverage inside the institution or adjacent locations; also, the user may use free wireless hot spots provided by government or private institutions through different programs;
- Mobile carrier data connections over GPRS or 3G that allows permanent connections in areas covered by a mobile carrier; these services imply supplemental costs for users but in many cases students benefit from different promoting programs that will lower the cost or offer limited transfer with the voice service; it allows almost anywhere connection and access to mobile learning services in places where conventional networks are unavailable; taking into consideration the cost impact that is directly related to the amount of transferred data, developers of m-learning applications must concentrate firstly on reducing this size.

Despite the fact that the m-learning process is not fully defined and it is in a continuous development, there are categories of applications that are already implemented and in use for many years:

- Standalone applications that provide standalone services or communicate with the system using WAP or Socket technologies; depending on the device operating system, these applications are developed in Java or in .NET Compact Framework;
- Web browsing using WAP, GPRS or 3G technologies; it gives access to online resources as courses, suggested bibliography, multimedia presentations; taking into consideration the connection bandwidth, amount of transferred data and the device display, the Web content must adjust its size and quality dynamically; developers must set as objective an optimal level for the quality-cost balance;
- SMS Alert services are provided by the mobile carrier as a request made by the m-learning provider; this solution is very cost effective and also has a great communication impact; as every student has a mobile device used also for voice communication this application type has a full coverage over its users; also, this service has the minimum time for data communication;
- IVR (Interactive Voice Response) services offer support or useful information to users using voice communication technologies; it may be considered an alternative to the web based solutions;
- Email services for mobile devices has become possible as many Smartphones and PDAs come with POP3 email clients that use any available data connection to retrieve email messages from the server;
- PushToEmail is a service offered by the m-learning provider with the mobile carrier; this application allows email transfer using the mobile carrier network; initially the technology was introduced by Blackberry devices but in recent time many vendors has implemented this facility in their mobile devices;
- OnlineSharing of data or multimedia content; shared resources may be uploaded or accessed using this type of application;
- WebQuest [11] is a Web based application that requires students to interact with it on a specific topic; this application implements an inquiry-oriented activity and allows students to access resources and to upload data regarding the WebQuest topic;

The technologies that allows the implementation of the described types of applications are already developed .NET Compact Framework or J2ME and offer the

means to develop and implement the m-learning architecture.

5. Quality criteria

The application quality is a term that allows many interpretations, but despite this flexibility it preserves its place as the most important criteria in analyzing the software product. It is important for both developers and users. The m-learning application quality is described from the viewpoint of software quality characteristics. There many standards and quality characteristics systems for software applications, from which the most known is ISO 9126 [8], that are defining sets of software characteristics for applications. Taking into consideration this large amount of information and adding to that the cost and time limits of a software development process, we reach the conclusion that we must concentrate on a small number of quality characteristics. This set of quality criteria is defined selecting the significant characteristics set for the analyzed software product, the m-learning application. Without this condition, final results, regarding the application quality, are less precise. Also, the objectives of the development process are affected and resources are used in less important areas. Producers target to maximize quality levels improving those characteristics considered critical. The reason for that objective is based on the fact that resources are limited and the final quality/cost value must be acceptable.

Implementing and reaching the application high quality level represents only a stage in the complex process of development. One phase that precedes it is the identification stage of the quality characteristics with the highest impact on the overall quality level. Improving those particular zones leads to a user expected quality level.

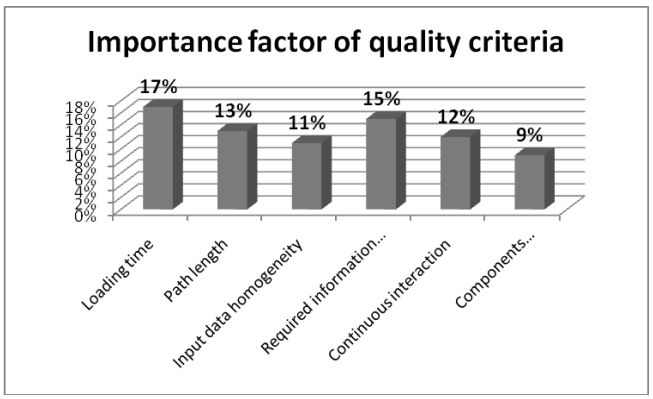

Fig. 3 Importance coefficient for m-learning quality criteria.

A survey realized on a group of 400 students in the computer science field, that will represent the users of an m-learning application, has helped define a set of quality characteristics that they have considered to be important from their point of view. The survey has analyzed 15 quality characteristics that were defined by both developers and users.

Figure 3 describes the results of the survey highlighting the first 7 characteristics, considered most important.

Quality criteria taken into account for m-learning applications are:

- **loading time** represents the time user waits for the page to be downloaded on local machine and to be interpreted by the browser; for m-learning applications that are not destined in particular to present information from the multimedia field and that don't contain large components, the loading time must not be greater than a few seconds; when developing the application, producers must take into consideration the minimum bandwidth available for most common Internet users that access the application; these represents an important factor that determines the loading time; regarding .NET or Java executable applications loading time means less memory requirements because mobile devices don't have the capacity of a desktop computer
- **path length to searched resources** is equivalent with the graph shortest path or the minimization of tree height; the path dimension is represented as the number of open pages until desired information is reached; it is considered that each m-learning application has a single start page, or homepage; besides the supplementary effort to read and search links to follow in each visited page, users must wait for each page to be fully loaded; that's why, the dimension of the visited path may be expressed as the sum of each node loading time;
- **homogeneity degree of input data process**; the way users interact with the application must be same in each component; for example, selecting a single option it is implemented in the hole application using a combo-box or radio buttons; a high level of controls and components diversity distracts users from their action and sometimes it represents an additional effort to use the application;
- **user required information level**; if there are used forms that require users input data, there must be indicated required and optionally fields, and must be implemented local data validation statements; also, the situations in which users must go back to the form page must not require the rewriting of the

hole data, only the wrong or not completed information; the application must minimize users effort to interact with it; for example, the search function requires with a minimum number of characters, abbreviates been accepted as input data;

- **continuity of human – application interaction**; there are avoided situations when users reach a dead-end path without having any possibility to select next page to view; despite the fact each browser allow users to go back to previous visited page, producers must plan to include controls and links that will offer multiple choices to select next page or to return to a particular one;
- **complexity, homogeneity and symmetry of used components**; the application must preserve an uniform character for all its components; this takes into consideration the way controls are disposed on the interface, how information is presented, the menu of each of application components, the way results are published.

6. Metrics for m-Learning Applications

The software metric is a mathematical model developed based on an equation that has the form $y = f(x)$.

A mathematical model contains one or more equations, inequations and has one or more objective functions. Its role is to describe the stage of associate system. The role of software metric is to measure a certain characteristic of a software application including all factors that influence the level of measured characteristic. Being applied to all software application from a homogenous set, the metrics become the instrument that helps making classifications and hierarchies of analyzed software applications.

Many M-learning applications use in the development stage a Web-based application type framework. The reason is given by the:

- capability of mobile devices to get web content through high speed mobile data connections like 3G; despite the display size, various techniques are used to minimize details and to emphasize information in Web pages requested by mobile clients;
- variety of instruments, programming environments and languages, techniques and methods used on a large scale;
- open software technologies that reduce the costs for proprietary tools;
- great number of on-line communities and free code libraries that reduce the cost of development from start;
- easiness to combine multimedia components into an application.

Because of that, this chapter analyzes the metrics from the point of view of a Web application highlighting the particularities of applying these metrics on m-learning applications.

Among the first utilized models of measuring the quality level of m-learning applications were the next indicators:

- dimension of occupied space;
- access count of a page or topic;
- number of pages read in a working session.

These metrics proved to be capable of analyzing the phenomenon only at a superficial level and could not be used to improve the quality of information contained in pages and also could not point out the factors that influence the quality level of m-learning application.

Based on measured attributes, the Web metrics are classified, as in [7], in:

- metrics that measure the properties of the associate graph; the application analyzed through her components, Web pages, defines a virtual graph whose nodes are represented by pages and the connections between them define the roads of graphs' nodes; the metrics based on graph's application analyze the structure both on high and detailed level.
- metrics that analyze the signification of web page; these indicators measure the level of quality and relevance of web page from the perspective of informational needs of users; the results obtained by applying these metrics are used to make an hierarchy sort by the relevance of the returned pages of searching engines.
- metrics that characterize the way of using the accessed web pages; the way that user interacts with web page offers important data used to define the content, the structure and presentation of the information; these metrics evaluates the user's behavior;
- metrics that measure the similarity level; these indicators describe the connections between pages;
- metrics for finding and searching that evaluates the web services performance of finding and searching information in web pages
- metrics of information theory; describe those properties of web pages regarding need, generating and using information;

The models used at defining these indicators come from various areas such as metrics software, finding information, sociology, econometrics, all being

adapted to serve the evaluation process of web applications' quality. Some of analyzed metrics are specific to web application field.
Figure 4 describes taxonomy of web metrics based on previous classification.

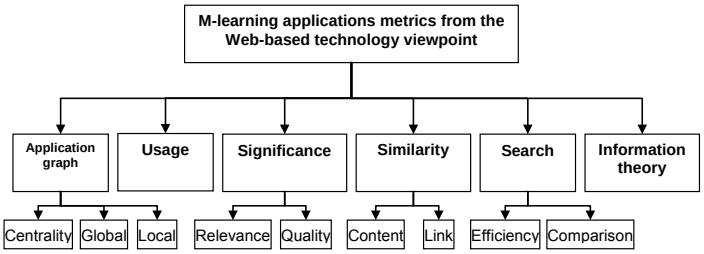

Fig. 4 Taxonomy of M-learning applications metrics from Web technology viewpoint, derived from [7].

From the general viewpoint of a software application, the metrics are used to measure main software characteristics as described in [8] and [9]:

- functionality; the metrics measure the degree at which the application reaches its main objectives, to assist students in the learning process with new tools and with necessary information;
- reliability; there are defined metrics around *fault tolerance* concept measuring how stable and error free is the application;
- usability; it is measured the effort required to understand and use the application;
- efficiency; there are analysed software and hardware requirements needed to execute the application at normal levels;
- maintainability; metrics measure the developer effort to modify the application by adding new components or maintain existing ones;
- portability.

7. Conclusions

Learning in the mobile age does not replace formal learning but, it offers a way to extend the support of learning outside the classroom, to the conversations and interactions of everyday life.
The quality of the m-learning application represents an important aspect for the education process because it affects the way the information is understand and is learned by users. Also, using m-learning instruments implies using information technologies and various IT instruments like personal computers, computer networks, mobile and multimedia devices. These, require a particular IT infrastructure and resources that cost more than the classical resources based on printed paper.
The optimization process of the m-learning application is a continuous process that aims an increase efficiency of this type of software applications and a lower cost for needed resources. These will allow a greater usage of virtual instruments and will increase the effect of other education instruments.
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