Analysis of M-Learning Applications Quality

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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. A characteristic of today's society is the increasing use of modern information and communication technologies in all areas. Investment in mobile device is an important step to improve the quality of life in our dynamic society.
The paper analyses the impact of m-learning on the educational process and describes software characteristics of m-learning applications. There are taken into consideration the fields that define m-learning processes as education, technology and software development. For the evaluation of characteristics levels are described metrics and measured values are used to determine the m-learning application overall quality level. The value is determined by aggregating each factor value and taking into consideration importance coefficient.

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

1. Introduction

In the last years, alternative ways to the traditional learning have been introduced, taking advantage of the latest advances in information and communication technologies: e-education or long distance education for those students that time and location don't allow them to attend traditional classes, multimedia centres and virtual libraries for those looking to enrich their cultural knowledge on demand.
Is not a news anymore that the Internet, mobile device and the advanced technology has influenced the way in which we perform our daily tasks, the way we live, the way we do business, the way we shop, the way we learn, the way we communicate and the way in which we spend our spare time.
The alternatives to the traditional learning, offer flexibility, speed and innovation.
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.

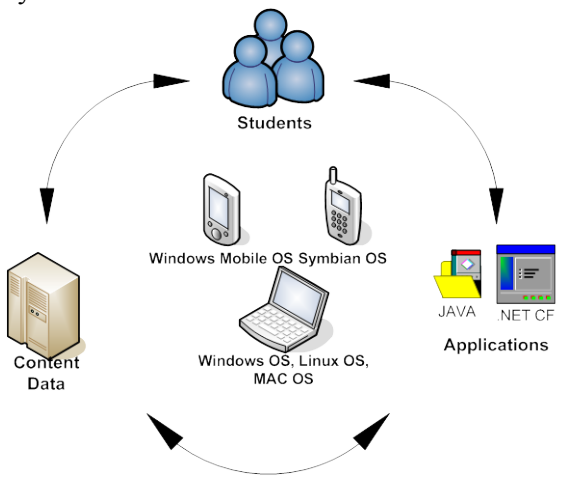

Fig.1 Mobile device integrated point

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.

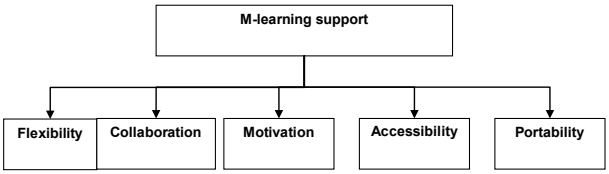

Fig. 2 Support of mobile learning

There are four main reasons that could be invoked in support of mobile learning (figure 2):

- Flexibility

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.

- Accessibility

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

However, when considering accessibility from the learner's point of view rather than the technology's, it can be argued that mobile learning goes on everywhere – for example, students revising for exams on the bus to faculty, doctors updating their medical knowledge while on hospital rounds, language students improving their language skills while travelling abroad. All these instances of formal or informal learning have been taking place while people are on the move.

- Portability

Juniu (2003) sustains that many benefits accrue when using handheld devices, the most important of which to the learners and teachers is the opportunity to take the learning experience outside of the confines of the classroom.

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

The student may have access to a multitude of different hand devices.

Mobile devices are offering a large number of benefits to students and teachers:

- familiarizes individuals with the mobile devices and educates them about the benefits of using advanced technology;
- provides integrated informative systems with social, cultural and economical aspects of the individuals;
- transparency of information;
- removes time and location barriers;
- promotes reuse of information;
- reduces operation time;
- reduces costs;
- improves information access for decision-making;
- cultivates better relationships with teachers;
- allows searches of large volumes of heterogeneous data (documents, pages, database, messages, multimedia);
- involves the students in everyday activities providing easy access to information using mobile devices.

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.

It is necessary to change educational methods according to the new technologies and with the access of knowledge through mobile device. A lot of results will be expected from students after they graduate. First of all, there are:

- Self to gain the information and knowledge and to integrate them;
- Active, independent and creative approach to problem solving; in both individual and teamwork manner;
- Ability to communicate;
- The contact between students and the real world of work.

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.

From the analysis of the m-learning process and use the recent study made from Yanis and Nikleia (2005), [12], it becomes obvious that a systematically correct and systemically complete definition of mobile learning must take into account many parameters and also ways in which they interact and influence each other. In order to be able to visualize, conceptualize, and hopefully later, study in greater detail such parameters and their inter-relations, we propose the following abstract formulation for the definition (1).

$$(1)\ \text{MLearning} = f\{\ t, s, Le, i, IT, M, m\ \}$$

t – time; whereas *t* was discontinuous and discrete for previous paradigms of learning (e.g. mainly whenever in classroom), for m-learning time during which mobile learning can take place may be continuous,[12].

s – space; the space is in m-learning is not a real place like a classroom, it represent more a virtual space;

Le – l-environment; the learning environment is different in m-learning because the "anytime, anywhere" capabilities of mobile device encourage learning experience outside of classroom;

i – informality; the information, the specific educational themes and chosen topics covered are now structured in a completely different way and follow different rules and priorities. The learner usually shifts from topic to topic and from discipline to discipline, in what might appear as a chaotic pattern;

IT – technology; this parameter is quite complex. It encompasses all technological aspects and momentary characteristics of both the hand-held device and the surrounding environment (i.e., services available, antennas, repeaters, external devices within reach etc.);

M – motivation; this parameter contains as a conglomerate of the learner's abilities, prior knowledge, preferences, momentary attention etc. In m-learning most of students are learn more when they are do something just in play;

m – method; the *method* is a conglomerate of all parameters related to delivery of and interaction with content. These may include pedagogy, philosophy as well as technical and logistical aspects such as method of presentation (or assessment), [12].

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 3, 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; also, in [14] it is described a multi-agent system within the context of E-Learning environment that can be extended over an m-learning system; 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.

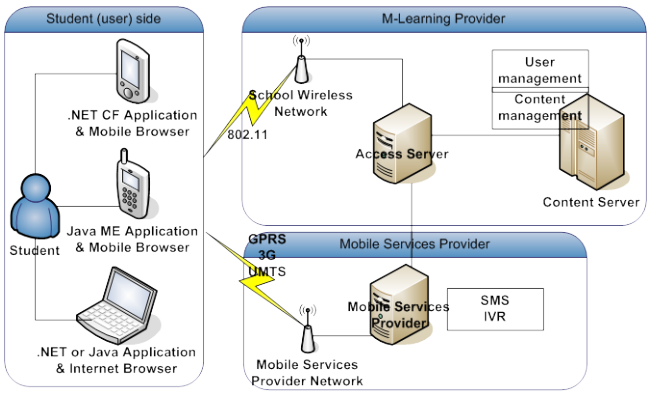

Fig. 3 Entity architecture of an m-learning process.

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.

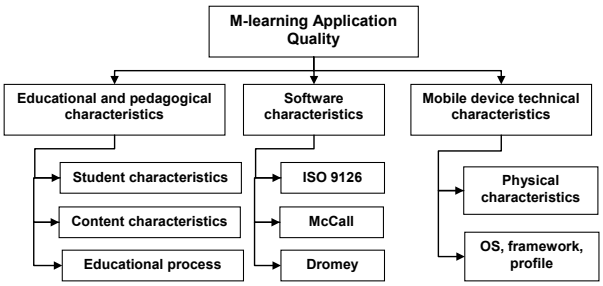

Fig. 4 M-learning quality factors.

M-learning applications are influenced by factors from different fields:

- software development because it is a software product;
- technical domain associated with mobile devices because the application is intended to run mostly on mobile communication devices and less on personal computers;
- education and learning because the application objective is to support the educational process, to deliver knowledge.

All these elements impose a quality level that can be reached at global level only by analyzing each layer separately, as described in figure 4.

From educational point of view, the m-learning applications quality is defined by criteria regarding:

- pedagogical elements that allow users to interact with each other and with the tutor, to define their environment or to communicate;
- students characteristics as knowledge level, age, special abilities or disabilities;
- educational and learning processes that describe ways and techniques to deliver knowledge, to test learners, to get feedback or to orient the process towards the learner;
- educational content that may impose a special format for data storing or delivering; for example, a music lesson requires mostly sounds and an art one requires pictures and movie clips, [16].

From the device viewpoint, there are technical characteristics that influence m-learning application quality:

- user interface that allows users to interact with the device;
- communication capabilities that mange data transmission between multiple devices and with a central point;
- operating system and internal process that manage the m-learning application and offers support;
- physical characteristics regarding dimensions, weight, type of display, keyboard, presence of a

digital camera, compatibility with other external devices, hardware [17].

This factor is difficult to control because there a many mobile device vendors and each implement unique features in their products. At some levels, some of these characteristics are standardized and the m-learning application must be developed around that low level. In this way, it will cover a wide area of devices and the problems derived from each device particularities are reduced.

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 by 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.

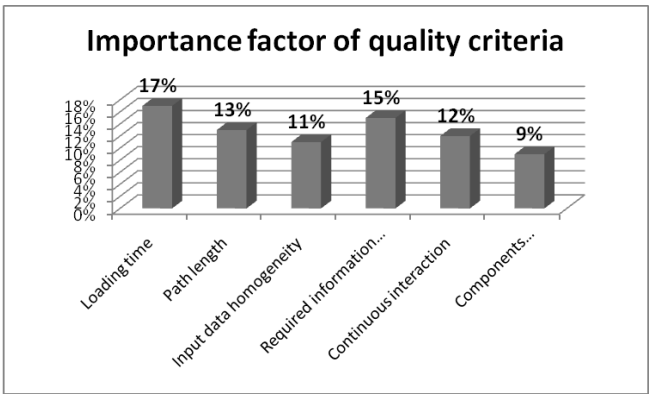

Fig. 5 Importance coefficient for m-learning quality criteria.

A survey realized, for this study, 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 5 describes the results of the survey highlighting the first 6 characteristics, considered most important. These characteristics cover over 75% of the m-learning application quality.

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; for an executable application, loading time represent the execution time;
- **path length to searched resources** is equivalent with the graph shortest path or the minimization of tree height; the path dimension is represented by the number of open pages, forms, 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; this scenario also applies to forms based application like ones developed for Windows Mobile or Java MIDlets;
- **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.

The analysis has highlighted that the first two important characteristics are *loading time* with a 17% importance coefficient and *user required information level* with 15%. From this point of view, the users are more concerned about the cost of using the m-learning application, cost measured by the time needed to receive and use the content. These two characteristics have an impact also on the financial cost represented by the user mobile monthly subscription, if the m-learning process requires mobile wireless data connections.

The other quality characteristics that received a low level of importance are:

- **complexity level of multimedia formats**; today mobile devices allow developers to use rich multimedia formats as video, audio, graphics and multiple text formats; a high degree of complexity level of multimedia formats may affect learners focus and has a high impact of the application size or the amount of network transferred data; the advantage of using various multimedia formats is that it can concentrate and highlight ideas in a far better way than text;
- **degree of communication with other devices;** communication between the tutor and learners and between learners is an important factor in a learning environment; for m-learning applications there is not a direct channel between them and everything is based on using devices, [14]; communication depends on the device integrated capabilities as infrared, Bluetooth, voice and text services, wireless; the m-learning application may use the device OS application protocol interface (API) and access these resources allowing learners to communicate;
- **application security** describes methods and techniques used to protect learners data and to authenticate the user; as mobile devices are more vulnerable to theft or losing them, the security factor becomes more important; as this study has highlighted, the learners consider this type of application less vulnerable and important than the access to the device or other personal data applications;
- **application size** describes the physical memory space needed to store the application and its resources; today's technological achievements in the mobile devices field and data storage, like memory cards, makes this a less important obstacle;
- **accessibility options**; mobile devices differ by their producer and also by their model; each has unique features like qwerty keyboard, more than two command buttons and touch up screens; the development of the m-learning application takes into consideration the variety of device specifications and define applications that can be used in different conditions; the minimum requirements is that someone could use the application with the only two command buttons that each mobile device has; is a disadvantage for the m-learning system to impose learners a standard regarding the device and its accessibility options;
- **complexity of use-case scenario** describes the difficulty or easiness encountered by learners to learn and then to use on a daily basis the application;
- **level of required feedback or tests integration**; the m-learning process covers all the aspects of a educational activity from teaching to testing; applications can integrate on-line or off-line testing functions; an approach based on selecting the correct answer is more appropriate for mobile devices;
- **number of user options and functions** describes what can user do with the application;

the minimum level for this characteristic is based only on two options, to open the application and to close it; from this point, developers may allow users to do more by implementing other functions like saving, restoring, copying and other application type specific routines;

- **application liability** describes the m-learning application capacity to be executed without unexpected and unwanted interruptions; the application must preserve its state and must offers user solutions to repair or avoid the exceptions; the competition between software developers has made this software characteristic a standard and users have reach the point where they consider it by default with a high level;

All the quality characteristics in this study have been selected from learners point of view and less from the developer one because the m-learning process must be learner oriented.

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 6 describes taxonomy of web metrics based on previous classification.

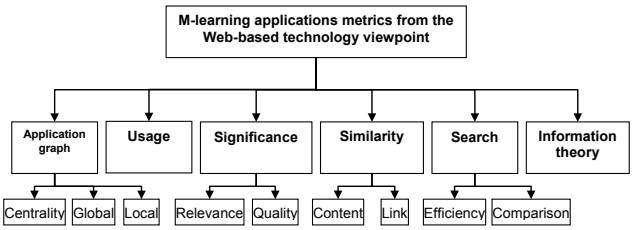

Fig. 6 Taxonomy of M-learning applications metrics from Web technology viewpoint, derived from [7].

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 measure the application capability to be installed and used on different hardware and software platforms.

From the mobile device point of view, the metrics measure characteristics that impose restrictions on the software component:

- device display metrics measure the resolution, physical dimensions, color depth;
- data communication interface;
- data input interface;
- hardware like processor characteristics [17], data storage, virtual memory;
- software support regarding device operating system, framework or profile for applications, virtual machines;

The educational characteristics are measured with metrics that analyze:

- users group from the viewpoint of their social background, IT knowledge levels, structural homogeneity;
- learning process from an educational point of view;
- content type as data presentation formats, multimedia elements, text characteristics.

All new defined metrics must be validated in practice. To assure comparability between results and also their objectivity, the metrics must be analyzed and tested before they are used in real-case scenarios.

7. Application quality level

M-learning application complexity requires to take into consideration a large number of analyzed software characteristics during quality analysis. This is a multicriterial process that is defined on a set of n software quality characteristics $QC_1, QC_2, ..., QC_n$, In this equation the QC_i indicator represents the measured value of a quality characteristic.
In order to determine the overall quality level of the application all the data must be aggregate into a single value. It will simplify the understanding of the application quality and it will allow developers to compare their product with other m-learning solutions or with an optimal objective.
Software quality characteristics differ between each other by:

- significance of directly measured value;
- optimum criteria; from this point of view software characteristics define two distinct sets that have an minimum criteria, respectively, a maximum one; if the QC_j characteristic defines a minimum criterion then the smallest value measured for this characteristic it is considered to be the optimal one; correspondently if QC_k characteristic defines a maximum criterion then its best value is the biggest measured; for example, analyzing the software characteristic that describes the number of pages or forms that must be opened till the desired resource, in other words, path length, the developers must design m-learning applications with the lowest possible level for this characteristic;
- characteristics importance coefficient in relation with the software product category; same characteristic has different importance for different m-learning applications depending on their objective, platform, user typology; the m-learning project management process, [15] must be learner oriented and must take into consideration his needs.

The necessity of considering optimum criteria as an important factor for the m-learning quality process is defined by the *AQ* aggregate indicator determination stage. This indicator describes the overall quality level of an m-learning application and it must comply with the fact that various characteristics have different ways to determine their optimal value. Normalized values are obtained based on measured values, qcl_j, using the (2) relation:

$$(2)\quad qcl'_j = \begin{cases} (-1) * \text{qcl}_j, \text{ if the } QC_j \text{ characteristic optimal point is a minimum one;} \\ \text{qcl}_j, \text{ if the } QC_j \text{ characteristic optimal point is a maximum one;} \end{cases}$$

The *AQ* indicator is determined for the application using the relation $AQ = \sum_{j=1}^{k} qcl'_j * qcic_j$ in which $qcic_j$ represents software characteristic QC_j, with $j=1..k$, importance coefficient.

Determination of characteristic importance coefficient represents a distinct process that describes each analyzed software characteristic importance in the solution overall quality image. This is a user oriented process because the objective is to determine what it is important for users, learners and tutors.

The *AQ* indicator has a low level of complexity despite the complexity of the quality criteria factors. It is needed a simple indicator that will allow developers to get a quality image of the m-learning application without many resources.

If the development process has a circular set of phases, based on developing temporary versions of the same m-learning application, the *AQ* indicator may be used to analyze the improvements that each new version has. It also represents the starting point in determining the quality zone that must be improved on the future version.

In the case of product comparative analysis, the AQ indicator is determined for each considered m-learning application. The solution with the highest value for *AQ* is considered to be optimal with the better quality level. Such analysis requires that each selected characteristic is measured for every application and the applications are in the same category and can be compared.

The results of the comparative analysis between different m-learning applications or between versions of a unique product are subsequently used to assess the influence that software characteristic dependency has on getting the optimal solution. This is done with a supplementary analyze of the characteristics correlation and by developing regression models around strong related characteristics. The obtained regression model is used to make a partial selection of the versions set with the highest probability to contain the optimal solution. This set is implemented into functional software versions that are measured and evaluated. The regression model acts as a filter and reduces the versions number in the development process by reducing the total number of cycles.

8. 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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