Assessing Effectiveness in Mobile Learning by Devising MLUAT (Mobile Learning Usability Attribute Testing) Methodology

Bekim Fetaji, Mirlinda Ebibi, Majlinda Fetaji

***Abstract*—** Mobile learning has been investigated from a range of perspectives, but there is little published research studies on usability of m-learning and its efficiency. Therefore investigated and analyzed the feasibility of m-learning by doing a review of published research in the past decade (2000 - 2010) analyzing successful m-learning projects and m-learning in general as well as realized analyses of advantages and the pitfalls and issues found. Based on this analyses provided are recommendations for improving m-learning in general. To have successful and efficient m-learning it is essential to devise and implement appropriate usability testing methodologies to evaluate the usability of mobile applications. The primary goal of this research study was to develop more efficient usability testing methodology that the authors called MLUAT (Mobile Learning Usability Attribute Testing) for m-learning and comparing its results with two other usability testing methods aimed for e-learning and applied in m-learning. Findings showed that the developed MLUAT methodology is more efficient and recommendations for approaching and improving m-learning are discussed.

***Keywords*—** m-learning, e-learning, mobile devices, usability testing, HCI for mobile devices

I. Introduction

Research into mobile learning also known as m-learning is thought to place Universities and institutions at the forefront of pedagogical excellence of practice, answering student requirements for flexibility and ubiquity: 'anywhere, anytime, and any device' access to information.

Mobile learning has been investigated from a range of perspectives, including the use and the potential of wireless technologies in education, technology adoption models, pedagogical approaches, architectural issues related to the design, usability of technology and m-learning and different aspects of human-computer interaction for mobile devices.

Manuscript received April 28, 2011: Revised version received Maj 26, 2011. This work was supported in part by the South East European University Research Center.

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It is a fact that m-learning, has not yet seriously impacted education and the projects addressing the adoption of mobile ICTs in schools can still be regarded as spearhead [12] . Although, there are a lot of successful projects for mobile learning documented in the research literature [11], and mainly the outcomes are positive, but yet not even scratched the high potentials it has.

Even though mobile learning is still in its beginnings (just more then a decade) and there are many aspects which still need to be justificated. In this analyses and literature review, we will try to investigate these aspects of mobile learning.

Thus, the focus has been set on investigating and reviewing m-learning.

Many reviewed researched studies [8], [6] and [17] have given encouraging results for using mobile technologies to support students in the teaching and learning process.

With the advancement of mobile devices and technologies presented during 2009 and 2010 especially with the introduction of new iPhone 3Gs and 4, then iPad tablet the m-learning opportunities have increased highly [23]. Schools and Universities embrace the use of iPad tablet as well as iPhone mobile devices as in [20], [26]..

To our knowledge based on extensive literature review of work published in this field, also there are little evidences in the research literature for usability testing methodologies and of m-learning environments in terms of the ease-of-use and efficiency of the user interface of the environment. Some evidences show that throughout empirical studies, there are some usability testing methods used. Majority usability testing include questionnaire surveys or interviews (in the place, telephone or email), or observational studies; or quantitative measuring of some usability attributes as: learnability [16; 14], efficiency [12; 14], simplicity [15], memorability [16; 14; 17], readability, learning performance, errors [14; 17] satisfaction [13; 17].

Usually, in designing mobile applications, usability guidelines for desktop applications are used, which are not appropriate and do not address the issues related to the current limitations of mobile devices which are supposed to be used as learning mediums. Also, there are various guidelines for usability testing of desktop applications which are not always relevant to mobile applications [13]. "The latest mobile devices are agonizingly close to being practical, but still lack key usability features required for mainstream use" [11]. There is a lack of methodologies ascertained as good usability testing methodology for designing usable mobile applications. Therefore, it is essential to devise and implement appropriate usability testing methodologies to evaluate the usability of mobile applications.

Which is the best usability testing and evaluation method regarding m-learning applications? It is a great challenge for the m-learning researchers and developers. Even though there are researches conducted regarding to best usability testing method for e-learning applications, it still can not be applied in m-learning concerning the above mentioned arguments.

Hereby, the goal of this research is to compare the results of two usability testing methods aimed for e-learning and applied in m-learning and the one proposed MLUAT usability testing methodology for m-learning [2]. A similar study to e-learning applications is done by [4] for web-based e-learning applications. The aim is to confirm the effectiveness of the proposed MLUAT methodology for usability testing of mobile applications [2]. To accomplish that a comparison study among the proposed MLUAT methodology with other two methodologies for usability testing following guidelines from [21] and [22] on the same m-learning system is done. Identified is the best one in a context of the extent (number and nature of) to which usability problems are detected.

Even though Heuristic Evaluation is shown to be fast, inexpensive, and easy to perform and satisfactory to identify the usability problems, we claim that MLUAT methodology, a combination of usability testing methods give better results not effecting much the cost-effectiveness of the process..

We have defined the tasks to be accomplished for the observation and the measurement of usability attributes and questionnaires (shown in Table 1) to be shared.

II. Analyses of M-learning Projects and Trends

According to [7] an increasing number of colleges and universities are adopting mobile wireless technologies as teaching and learning tools. According to [7] more than 90% of public universities and 80% of private universities in the US have some level of mobile wireless technologies, such as mobile wireless devices and networks.

According to [2] and [3] mobile wireless devices, tablets, PDAs and handheld devices are used most often in the learning environments.

Table 1 summarizes [2] 's findings about how 17 institutions of higher education have been using mobile devices.

According to [20] The New York City public schools in year 2010 have ordered more than 2,000 iPad tablets, 300 went to Kingsbridge International High School in the Bronx, or enough for all 23 teachers and half of the students to use at the same time.

More than 200 Chicago public schools in 2010 year applied for 23 district-financed iPad. The Virginia Department of Education is overseeing iPad initiative that has replaced history and Advanced Placement biology textbooks at 11 schools. And six middle schools in four California cities (San Francisco, Long Beach, Fresno and Riverside) are teaching the first iPad-only algebra course [20].

Table 1. Mobile Wireless Technologies Uses in Higher Education [7]

Schools	Users	Tool	Key Uses
North Carolina State University College of Veterinary Medicine, Raleigh, NC	Students	PDA	▪ Accessing to many medical references ▪ Participating in wireless polling during class
University of Central Oklahoma College of Education, Edmond, OK	Faculties and Students	PDA	▪ Accessing to information ▪ Supporting innovative teaching practices ▪ Enhancing collaboration and builds relationships
UC Berkeley School of Education K-12 Schools, Berkeley, CA	Students	PDA	▪ Offering students mobile data-gathering tool ▪ Allowing for new types of curricular activities ▪ Helping students understand difficult science concepts
Stanford University, Stanford CA	Faculty, students and staff	PDA	▪ Accessing data ▪ Enableing on-going communication among faculty, students, and staff. ▪ Data exchange
Carnegie Mellon University, Pittsburgh, PA	Students	Wireless Computer	▪ Collaboration
University of California, San Diego, San Diego, CA	Faculty and students	Wireless LAN	▪ Providing better networking service for laptops and PDAs
Florida State University, Tallahassee, FL	Faculty and Law and MBA students	Wireless LAN	▪ Providing better teaching and learning environment
Wake Forest, Winston-Salem, NC	Faculty and students	Wireless LAN	▪ Providing innovative technology ▪ Others

In Europe a research conducted by [8] involved mobile blended learning technologies to support HND computing students at the University of Wolverhampton.

The objectives of this project were to develop, deliver and evaluate blending learning opportunities that exploited SMS, WAP and VLE technologies. Initial research indicated that students used SMS text messaging promptly and effectively, and that they would prefer to receive notice board information such as room changes, appointments, feedback and exam tips via SMS rather than via e-mail or notice boards. SMS-based interventions took place over the second semester of the 2002-2003 academic year.

Initial test messages gauged the effectiveness and the level of timeliness of student responses to SMS text messages. A second set of messages was sent as feedback following the marking and moderating of assessments. During the trial, the students provided considerable positive informal feedback to the course leader, and a questionnaire administered to the students revealed that the majority of students thought the experiment was worthwhile.

Regarding to m-learning projects it has been found that the majority have been focused on improving interactivity in the classroom [4], [15] or on increasing students' access to learning materials anywhere, anytime as described by [1].

A smaller number of projects have focused on supporting on-the-job training in the field, largely for medical and nursing students in hospitals [8] & [5].

A few projects have included teaching students some aspect of mobile technology, such as programming mobile devices or using stylus technology, usually in connection with ubiquitous delivery [15]. Occasionally projects have combined ubiquitous delivery with a focus on interactivity with a single pedagogical focus. Several m-learning projects focus on how to apply e-learning techniques and content on mobile platforms. Several other free and commercial mobile language learning programs have recently become available [10]. Te BBC World Service's Learning English section offers English lessons via SMS in Francophone West Africa and China (cited in [10]); BBC Wales has similarly offered Welsh lessons since 2003 [10] and an EU-funded initiative known simply as 'm-learning' provides English lessons directed towards non-English speaking young adults.

A small number of projects span over more than one discipline area, for example [4] interactivity study in computer science and education.

Most projects focus on only one type of mobile device. Such project's need to expand into multi-institutional, multi-disciplinary approaches so that the outcomes are relevant to the widest community possible, using actual case studies in real class situations over a variety of subjects and education environments. The UniWap [14] project for developing and testing purposes use smart-phones and WAP phones.

Under the auspices of the European Union, the 'e-learning to m-learning' project establishes the first stage in the creation of the global provision of training on the wireless Internet [17], promoting and reinforcing the contribution to be made by vocational training. "From E-learning to M-Learning" is a long-time project that seeks to put in place a new virtual learning environment for wireless technologies and to develop course materials for a range of devices in this learning environment. The main pedagogical problems of developing mobile learning for PDAs [15] were solved in the project. The authors discuss the devices characteristics that are proper for learning and underline the move from d-learning (distance learning), e-learning, to m-learning. They attempt to predict which methods and technologies should be used for successful m-learning. 'Specifically and practically, this project will map the evolution from the wired virtual learning environment of today, to the wireless learning environment of tomorrow'.

III. Analyses of the Advantages of M-learning

Many studies have given encouraging results for using mobile technologies to support students in the teaching and learning process.

Students can use cellular phones (mobiles) for many purposes: smart card usage, browsing and accessing information in Internet or browsing electronic content from computer networks, databases and distributed file system; from anywhere, anytime, with minimal technical requirements. Mobile technologies help in optimizing the learning processes and services by means of added flexibility [14] in order to access information anytime, anywhere and promise the access to applications that support learning anywhere, anytime [6]. Learning can be available and immediate at appropriate time and from any location.

Opposite to computer technology, mobile technology is not connected to physical location. It is unique in allowing ubiquitous learning and mobility in learning according to [1].

Mobile technologies can offer "just enough, just in time, just for me" model of flexible learning [6]. "Just-in-time" instruction via mobile devices is very important and giving opportunity for education to distance students. Online access to information "just-in-time" rather than searching for hand taken notes makes the leaning process more efficient.

The high portability, flexibility, immediate reachability, personality, and accessibility are very appropriate and enhance the learning process [1]. Mobile devices are easer and lower cost to supply then a computer. They are ease-to-use, supply connectivity, interactivity, providing information on real time when needed increases user accessibility and satisfaction of the offered services in real time.

Portability and versatility make mobile devices a powerful medium for teaching and learning [17]. The portability features of mobile devices and portable and wireless technologies enable learning from anywhere, anytime without time and location constraints enable students to use their time more efficiently. Their portability and low cost offer surprising technical capabilities for the development of new systems [18].

Mobile devices perform many of the functions of desktop computers, with the advantages of simplicity (being easier to learn and use) and improved access (being usable anywhere, anytime), except the bandwidth, cost and input capabilities [18], which in most cases are the documented limitations of using mobile devices for learning.

[11] identify five properties of mobile devices (handheld computers) which "produce unique educational affordances" and those are:

a) Portability
b) Social interactivity
c) Context sensitivity, the ability to "gather data unique to the current location, environment, and time, including both real and simulated data"
d) Connectivity, to data collection devices, other handhelds, and to networks
e) Individuality, "unique scaffolding" that can be "customized to the individual's path of investigation"

In their review of mobile technologies [2] and [3] have identified the advantages of handheld devices, where is stated that 'these devices: i) are increasingly able to carry media-rich content and thus to support a conception of teaching focused on the teacher and on the content, ii) increased interaction with educational materials, for example the capacity to bookmark and annotate them, will strengthen this'. Mobile devices, besides supply text functions, Internet access, audio and video capabilities.

There are advantages in using a mobile device offering individual, private and learning at own pace and learning within specific contexts which can provide ‘reliable cultural and environmental indications for understanding the uses of information which may enhance encoding and recall and enable learners to access relevant information when and where it is needed’ [19].

IV. Identified Issues and Drawbacks

Mobile devices can be more easily integrated across the curriculum than desktop computers [17] and in a classroom environment without any extended requirements because of the environment infrastructures and the context of use. But, many obstacles in mobile usage which directly influence mobile devices’ and applications’ usability are encountered. The diversity and size of the screen, the low performance, limited memory (for images and multimedia content), limited display resolution and storage capacity, limited file types supported, and reduced input method, small keypads and keys; different platforms and operating systems used by different models [19], directly influence and make the usage of mobile devices (in the learning process) difficult.

In [13] that the technological capacity of all mobile devices has increased dramatically [23], [24]in the past three years. Screens are bigger and better, systems have more memory, and have more multimedia capabilities; as well as there are more sophisticated methods for inputting data” [6].

Mobile phones, tablet computers, and other handheld devices are no longer just for chatting and organizing contacts and diaries, they are now pocket-sized computers and as such have the ability to deliver learning objects and provide access to online systems and services.

The arrival of multimodal handheld devices such as the iPhone, android based mobile devices, and the enabling of GPS are continually adding to these learning capabilities’. The ongoing development of broadband wireless networks and the quick increase of power and capacity of the up-coming generation of cellular phones strength the potential of mobile technologies in education [2].

Technology is rapidly advancing and the documented limitations will not be obstacle in the near future for using these devices and having better learners experience.

Because of continuous advances in mobile hardware technology and communication, evolution of functionalities and the ubiquitous availability of wireless networks, mobile devices are getting increasingly more powerful in terms of computing power, memory storage, and network capabilities.

Still, obstacles exist and directly influence the usability of m-learning, which is limited and driven by the hardware and software constraints of mobile devices:

– small screen size or the form factor, low screen resolution [10]
– low storage capacity and network bandwidth [10]
– limited processor performance [2]
– short battery life
– compatibility issues
– lack of data input capability [18]
– high - cost browsing through GPRS and 3G / 4G technologies

These limitations make use of mobile devices and application a bed user experience, consequently not usable. The mobile screen is not equal to desktop screen. It is not sufficient space on the screen to display greater amount of information. Users’ need to focus on the environment rather than the interface so output is limited [18]. It is not sufficient space on the screen to display lot of graphics either. The mobile application interface shouldn’t become a scaled desktop application interface. The information may not appear properly. A vast amount of information in a small screen might affect the users’ recognition. Due to the low graphic resolution and limited greyscale (number of colours), the interface objects and multimedia information may appear despoiled and not obvious with the disgraced display quality. Due to degraded visual appearance of interface elements in mobile screens, the quality and efficiency of acceptance and understand-ability of the learning content suffers.

Desktop applications cannot be accessed via mobile devices and be displayed same in a mobile screen. “What works well on a large screen does not necessarily work well on a small screen” [10]. Most existing computer based learning management systems still do not have access support for mobile devices, and there are deficiencies in cross-platform solutions of LMS [4].

Even more, many mobile browsers do not support scripting or plug-ins, and do not have available memory to display desktop pages and graphics. This directly influences the usability of mobile learning systems. Web content that is mostly the format of electronic learning content is poorly suited for mobile devices [18]. The ability to display information in various multimedia formats is limited.

The small and limited display size and resolution of these devices and interaction styles impose new interface designs [25, 26]. In this context, the interface has many constraints, needs to be simpler and might contain less number of components and objects. It needs to fit all in one small screen. Usually, the human computer interaction in designing mobile applications is left behind without consideration. In order to address these issues a case study experiment in the scope of this thesis was initiated. It involves development of a web-based mobile application that students can use and learn within a particular study program [24], [25], [26] .

These usability issues of mobile devices and learning must be considered and carefully examined during the usability testing of a mobile application in order to select an appropriate research methodology and reduce the effect of contextual factors in the usability testing’ outcomes [8].

V. Research Design

The focus is on the following research question: To what extent do the findings of the three usability evaluation methods, the proposed MLUAT usability testing methodology, Qualitative testing, and Heuristics Evaluation of the m-learning system correspond among and to what extend does each method detect usability problems?

A comparative evaluation study on a MobileView [1], prototype of an m-learning system built for testing purposes described in [1], is conducted. We explore and compare the results of the usability evaluations by proposed MLUAT usability testing methodology, Qualitative testing using questionnaire and observation, Quantitative testing measuring five usability attributes set in the proposed methodology and Heuristics Evaluation method with relevant experts. The evaluation was conducted in a conjunction of Nielsen's 10 usability Heuristics [6].

We have selected, according to Nielsen for 5 users quantitative testing [5], while 20 users for qualitative testing [7], the potential users of the system. For the HE method the optimal number for cost-effective evaluation is 2-4 experts [9], we choose 3 evaluators, Master students in Software engineering direction in SEEU, Tetovo**.**

VI. RESEARCH INSTRUMENT

We have used and adapted the evaluation criteria to design the questionnaire according to [4] for m-learning shown in Table 1. Also, the questionnaire is based on the proposed guidelines for designing m-Learning applications in the scope of the research conducted in [3]. The questionnaire can be found in APPENDIX 1 of this paper.

VII. RESULTS AND FINDINGS

1) As stated above, the purpose of this study was comparison of the usability problems detecting by experts (using usability heuristics) and students (using qualitative testing). The number and the corresponding finding percentages of problems are shown in Table 2.
2) The problems identified were classified according to the usability category based on the used usability principles. The number of problems identified by experts and testers (students) for each category and the number of problems common to both evaluations are shown in Table 2.
3) Of the finally 41 problems in total detected by both groups, 34 problems were identified by experts group which corresponds to 83%, and 27 problems were identified by testers group which corresponds to 66%. Little more then three quarters of problems are identified by experts, and only little more then the half of problems by students. Students are not as good as experts in identifying usability problems. We can conclude that neither experts can identify all usability problems and are not ideal, nor students can. 20 problems were identified in common, and all mutually correspond to 49%. It is obvious that the experts' group identified much more usability problems then users whereas 49% were identified in common. That means that the half of the problems was identified by both groups (20 out of 41).
4) Moreover, the students identified 20 of 34 (59%) of the problems identified by experts. Correspondingly, the experts identified 20 of 27 (74%) of the problems detected by students (testers). It is obvious that experts identified almost three quarters of problems identified in common, while students slightly more than half of problems identified in common. These results demonstrate not a high correspondence between the results of the two evaluations.
5) The comparison in the number of problems found in common per each category/per group in all categories: Visibility of system status, Match between the system and the real world, Learner control and freedom, Consistency and loyalty to standards, Error prevention and recovery, Recognition rather then recall, Flexibility and efficiency of use, Minimize information on screen, Recognition, diagnosis, and recovery from errors, Design for small screens): 5%, 10%, 5%, 5%, 5%, 10%, 5%, 10%, 10% which are obviously low and 35% respectively. The results showed low level of common detection of identified problems from different categories by the two groups, while the highest level of common detection (35% which is pretty high in comparing to other cat.) were found in the last category 'the design for small screens'.
6) Of the finally 52 problems in total detected by MLUAT methodology, 41 problems were identified by HE and QUT which corresponds to 79%. Three quarters of problems are identified by experts and qualitative user testing using questionnaires. Adding observation and interviews increases the number of problems detected for 21%. HE and QUT could not detect all usability problems indentified. We can conclude that neither experts can identify all usability problems and are not ideal, nor students can. It is obvious that using the MLUAT methodology much more usability problems are identified then using only HE and QUT. These results demonstrate a correlation between the results of the two evaluations. Using MLUAT methodology for usability evaluation, the number of usability problems detected is increased.
7) The research investigates the extent to which heuristics evaluation by a small number (4) of experts and qualitative user testing using questionnaire of 20 users can identify usability problems in a mobile learning application. Moreover, it investigates to what extent the proposed MLUAT methodology can identify the usability problems in comparison with the best from heuristics evaluation and qualitative user testing. A comparison of the heuristics evaluation results with those of the qualitative user testing was done, using evaluation questionnaire designed based on the Nielsen's usability heuristics [8], Shniderman's eight golden rules [10] and the proposed framework for m-Learning Usability Design Guidelines.
8) Although the number of students was 20, 5 times grater then experts, they identified a lower quantity of the total number of problems, 49% in opposite of 83% of the experts. Experts identified 74% of students' problems,

while students detected 59% of experts' problems. Students (users) are not as good as experts, but experts are not superior in detecting usability problems. The low level of problems identified in common by each group is even one more factor which alludes in incorporating both usability evaluation methods.

VIII. CONCLUSION

We can conclude that heuristics evaluation is a proper, effective and fast usability evaluation method of m-learning applications with better results then the qualitative user testing, but still 26% of problems identified by students were not identified by experts. The combination of both evaluation methods showed to be a good strategy for detecting more usability problems which are incorporated in the MLUAT usability testing methodology.

According to the evaluation results, the MLUAT evaluation used to detect more problems then HE and QUT. Adding observation and interviews and quantitative usability testing increases the number of usability problems detected for 21%. HE and QUT could not detect all usability problems indentified.

It is concluded that MLUAT usability testing methodology is more effective and efficient usability evaluation method of m-learning applications with better results then the HE and qualitative user testing separately and in combination.

In the near future, it is expected that learning will move more and more outside the classroom and lectures halls into the learners environment both real and virtual negotiated by mobile devices.

There are identified specific problems in university learning that mobile technologies can help overcome, for example, limited real world context, limited access to learning resources, low student engagement in classes, and lack of practical experience in learning about mobile technologies. Instead of assuming the importance of m-learning, these problems together with the gaps uncovered in the existing m-learning body of knowledge as discussed below, have informed the choice of our research suggestions that address our overall aim of enhancing student learning.

Some findings show that introducing new forms of learning and teaching (even if this means just using a standard tool for drawing) improve the overall students' results [18].

The use of mobile and handheld devices within different modes of learning has made an impact in work-based learning (learning through work) which is an important way to acquire knowledge and skills today.

As discussed by [17], handheld devices: i) allow learners to distribute, collect, and share information with easiness, resulting in more successful collaboration; ii) can be applied as academic support for learners; and iii) the portability of devices coupled with wireless connectivity is bringing significant benefits to learners in terms of flexibility of access to learning materials. Even more, mobile devices can also be used for other generic learning activities such as gathering information, evaluation by ranking or rating, reflection, problem solving or skills acquisition [8] and [5].

In the research of [10] about supporting mobile learners, they claim that mobile devices are good tools to engage non-traditional learners; they remove the formality, which is considered among the most frightening aspect for those who have not engaged with learning; and that that the use of mobile devices improved retention of learners.

[12] stated that mobile devices can be engaged as tools to allow learners to construct their own understandings of a matter, thus to promote deep learning and critical thinking. Whilst [18] have explored the use of mobile devices and concluded that they support hands-on scientific experimentation and learning.

According to the report on Researching mobile learning [14] as valued by students', employment of mobile device include that it:

– facilitates individual, co-operative and interactive work in class

– enables the sharing of ideas and responses and the building of knowledge

– increases participation in whole-class settings

– enables learners to revisit areas for consolidation and reflection out of the classroom – this helps to increase understanding

– provides opportunities for autonomy and independence

– provides work and resources in one place, and to hand

– gives the ability to transfer work between digital devices and to and from other areas such as shared drives and learning platforms,

– Alleviates pressure on the computer rooms and makes learning more flexible.

Mobile devices have become tools to serve simultaneously teaching and learning alongside with work and leisure, in both formal and informal settings; the authors found out that mobile phones were generally used for contact, coordination, interviews, thus motivating learners; while mobile devices are presented as enormously resourceful tools that enabled access to a wide range of information [8].

[7] in their investigation of the use of handheld devices to support adult learners, found out that the 'anytime, anywhere' access to learning resources is an important advantage of the handheld computer, enabling learners to integrate their learning and other activities according to their time schedule.

Investigating the impact of mobile technologies in teachers' practices, from the findings show that devices serve teachers' personal purposes and considerably planning their teaching with dairy and address functions and preparing teaching recourses using recording function of devices.

Mobile devices are often mentioned as mediums which also facilitate personal and learning activities of people with handicaps or special needs.

[10] recognize that mobile computer-like handheld devices would have the advantage of a graphical interface which would facilitate persons with physically distributed cognition.

APPENDIX

Table 1. The questionnaire designed based on the adapted Evaluation criteria for m-learning context [12] the proposed guidelines for designing m-Learning applications [8].

Questionnaire: General interface usability criteria (based on Nielsen's heuristics and Sniderman's ten golden rules [8; 10; 4] modified for m-learning context) Range of criteria ranging from "Strongly agree – to Strongly disagree" for each question of each group (Lickert type scale of five provided options)
Visibility of system status • The system keeps me informed about what is going on • The feedback is given on time and right. • The important information is visible within the interface. • The results of each operation I perform are visible. • The system's interfaces does not attract much attention (with too much colors, or animations, graphics). • The menu and link design is: 1) clear with easily interpretable labels, 2) consistent during a navigation, and 3) predictable to see the results of performed actions based on the past interaction history Write down any problem found using the MobileView related to the section.
Match between the system and the real world • The used terms, phrases, symbols, and concepts, are written in every-day language. • The symbols, icons and names of the interface are intuitive, understandable and meaningful for the context of use. • The Information is arranged in a natural order • The information is logical and understandable. Write down any problem found using the MobileView related to the section.
Learner control and freedom • I can control the system. • I can exit the system at any time even when I've made mistakes. • There are facilities for Undo and Redo. Write down any problem found using the MobileView related to the section.
Consistency and loyalty to standards • The same concepts, words, symbols, situations, or actions refer to the same thing. • The interface design is consistent. • The functionality structure is consistent throughout the overall design • The interface design, tasks and functionality structure of a system is consistent [8]. • The navigation is natural and easy. Write down any problem found using the MobileView related to the section.
Error prevention • I do not easily make serious errors. • When I make an error, the application gives me an appropriate error message. Write down any problem found using the MobileView related to the section.
Recognition rather than recall • Objects, options for selection, and actions I can take are visible. • I do not need to recall information from one screen to another. • Instructions on how to use the system are visible or easily retrievable whenever appropriate. • Displays are simple and multiple page displays are minimized. Write down any problem found using the MobileView related to the section.

Flexibility and efficiency of use • The system accommodates different levels of users, from novice to experts. • Shortcuts are provided without attracting attention. Write down any problem found using the MobileView related to the section.
Minimize information on screen • The information is relevant. • There is not unneeded information, • The information is short, concise and understandable. • There are not too many screens [8]. Write down any problem found using the MobileView related to the section.
Recognition, diagnosis, and recovery from errors • I can understand easily the Error messages. • I can quickly, and in a simple manner get recovered from errors. • If I typed a command which results in an error, I do not need to retype the entire command, but repair only the faulty part. (no, it is hard with the device keyboard; colores attracted attention). Write down any problem found using the MobileView related to the section.
Design for small screens [8]. The system: • There is back (to previous page or screen) and exit option • All information fits in one screen (I do not have to scroll down and up) • The system uses the same metaphors, phrases, symbols and icons as we are used to with desktop applications. • The treeview navigation is simple and undemanding • Colors (fewer colors) are used attentively and do not attract attention. • The look and feel of the interface is pleasant and does not contain modified objects. • Pages fit to the display area of the screen; • On each screen, provide is a title of the screen; • Offered are links to change to the next screen. • The visited links are marked with different colours or underlining; • The learning content is presented in small textual files and audio files; • The information in the system's interface is located in accordance with devices' interface information appearance; • The same metaphors, phrases, symbols and icons as students are used to with desktop applications and devices input method (mainly keyboard) are used; • I do not have too many times to press buttons, view links, scroll to find out the needed information; • Opportunities to change the font size and type, colours and brightness are provided; • The colour contrast of background and foreground is visible and easy perceptible; Written down all problems found using the MobileView related to the section.

Table 2. Usability problems detected in HE and QUT

% Usability Problems	1.Heuristics Evaluation by Experts		2.Questionnaires		# HE and QT in common		Mutually (1. and 2.)		MLUAT		In common (HE and QTQ and MLUAT)		Mutually (1. and 2.)	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Visibility of system status	5	13 %	2	7%	1	5%	6	15%	7	14%	6	15 %	7	14 %
Match between the system and the real world	3	9%	2	7%	2	10 %	3	8%	3	6%	3	7%	3	6%
Learner control and freedom	2	6%	1	4%	1	5%	2	5%	4	8%	2	5%	4	8%
Consistency and loyalty to standards	3	9%	2	7%	1	5%	4	5%	5	10%	4	10 %	5	10 %
Error prevention and recovery	2	6%	1	4%	1	5%	2	5%	2	4%	2	5%	2	4%
Recognition rather then recall	2	6%	3	11 %	2	10 %	3	8%	5	10%	3	7%	5	10 %
Flexibility and efficiency of use	2	6%	1	4%	1	5%	2	5%	3	6%	2	5%	3	6%
Recognition, diagnosis, and recovery from errors	3	9%	2	7%	2	10%	3	8%	5	10%	3	7%	5	10%
Design for small screens	9	27 %	11	42 %	7	35 %	13	33%	15	29%	13	32 %	15	29 %
% of all problems detected	**34** (83 %) (65 %)	100 %	**27** 65% 52% MLUAT	100 %	20 (49% in common of mutually)	10 0 %	**41** (79% total in ML UAT	**100%**	**52**	100%	41 (79 %) of total	100 %	**52**	**100 %**

ACKNOWLEDGMENT

The Authors thanks South East European University Research Center for the financial support.

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