A Model for Integration of m-Learning into Learning Management System

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Abstract - *Mobile activities and services are present worldwide. Education follows these trends. Although it seems natural to use powerful small portable devices, capable of presenting rich content, basic educational goals imply designing solutions for the use on the most common device – mobile phone with GPRS and JAVA technologies, rather than elitist ones.*

This paper describes an approach to blending mobile learning into the existing e-learning system in the Laboratory for e-business, Faculty of Organizational Sciences, University of Belgrade. We have conducted a research in order to determine possibilities for introducing mobile learning into this system. Based on the results of the research a pilot project was carried out. The results show that mobile activities contribute to efficiency of the education system and are willingly accepted among students.

Index Terms — *blended learning, content delivery, mobile devices, mobile learning, WCSS*

1. INTRODUCTION

Mobile technologies are widely present in many areas of human activities: communications, business, fun industry, etc. Education also incorporates them. M-learning can be seen as learning on the go, mediated through mobile technologies.

M-learning happens across locations and takes advantage of learning opportunities available through portable devices. Learners tend to use whatever available technology asset for accessing necessary information. In that light, mobile telephone emerges as a device that is handy, always with the user, always on, and with available Internet connection. In the continuum of electronic devices used for learning there is a tradeoff between functionality and mobility. Although learning materials can be accessed from different places from laptop computers, or even desktop computers true mobility is connected with using small and lightweight devices, those "which a lady can carry in her handbag or a gentleman can carry in his pocket" [1].

2. CONCEPTS OF M-LEARNING

A. Advantages and disadvantages of mobile learning

Main advantages of using mobile devices in e-education are:

- It makes possible learning anywhere and anytime. The time formerly spent in transport or similar activities can be used for learning, checking results, etc.
- A small device has enough memory to store a huge quantity of data which sometimes replaces considerable amount of books and papers, and makes moving easier.
- It provides for registering and data entry on the practical lessons outside, where the desktop computer is not available.
- Mobile devices are in most cases less expensive from the desktop computers.
- Just-in-time learning – it can be used for data access on-site, for instance for the use of step-by-step tutorials for solving some practical problem.
- SMS can be used for delivering information like the changes in the class schedule or similar. This way of informing is much faster than the email.
- Mobile device is always with the student and is naturally personalized, unlike desktop computers shared among several persons on the faculty.
- The interaction among students is more intensive.

Major disadvantages of m-education are mostly of technical nature and some of them like processor strength, battery autonomy or the speed of mobile connections will be solved with development of technology. The others like small screen size or the absence of keyboard or mouse are connected with the small size of the device, and will be present in the future too. Maybe touch screen or voice entries are going to solve the problem of input, but screen size, text representation and navigation through text will remain a limit. Despite all disadvantages, m-learning is becoming more popular with the development of mobile technology.

Major disadvantages and constraints of m-education include the following [2]:

- Existing learning materials and applications are designed for the use on desktop computers and have to be customized for the capabilities of presentation on mobile devices.
- There are different types of mobile devices. Even when concentrating only on mobile phones, one faces a huge variety of models with

different features and capabilities. This implies that not only “small”, but different sizes of small have to be present, when it comes to content delivery.

- The majority of the mobile devices do not have classical keyboard or mouse, but use other ways for entering data. The navigation through the applications is more difficult in this way and has to be encountered when designing the software and learning materials.
- The accessed bandwidth in a mobile environment is always narrower than in a wired environment.
- M-education offers possibilities for learning in different surroundings which can be full of distraction and therefore fragment the concentration of learners.
- Solving security problems in mobile environment is expensive.
- Battery capacity determines the autonomy of the device.

The drawback of using mobile devices for education in Serbia is that the market of mobile services is not yet fully developed. Mobile access to the Internet is expensive for most of students.

B. Technical aspects of delivering mobile content

Content is delivered to the mobile devices by the means of WAP (Wireless Application Protocol). Typical mobile browsing scenario (PULL scenario) is shown on the figure 1. The request goes from mobile device, through wireless network to WAP Gateway/Proxy, where the request is forwarded to Web server through public Internet. Requested content is located and sent back as a HTTP response to WAP Gateway/Proxy. There, it is sent back to mobile device trough proprietary wireless network.

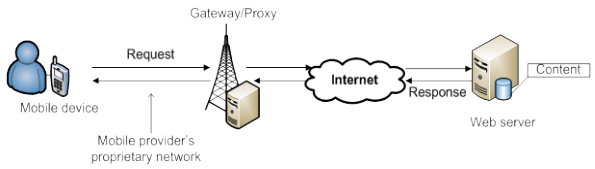

Figure 1 Typical PULL scenario and passage through WAP Gateway/ Proxy

WAP 2.0 supports WML and XHTML MP while WAP 1.x supported only WML. WAP 2.0 supports WCSS and makes possible customization of the output. In WAP 2.0 gateways act more like proxies. While WML supported WMLScript for client side scripting, first versions of XHTML MP present from year 2001 could not support client side scripting. From version 1.1, available since 2007, XHTML MP supports ECMAScript for client side scripting.

Table 1 WAP 1.x vs. WAP 2.0

WAP 1.x	WAP 2.0
Only WML 1.x	WML 2.0, XHTML MP
Gateway	Proxy
WAP stack – HTTP stack transformation	WAP stack like HTTP stack with wireless profiled TCP and HTTP
Binary – Textual transformation	

Principle of proxying the content is used in mobile browsers Opera Mini and Mozilla Mobile. These browsers force the proxying of content via their servers where the customization of the pages for mobile delivery and compressing of files for quicker pass through the wireless network is done.

Other approach is the customization and content adaptation at the origin server, known as server side customization. WCSS themes are chosen per session, based on the detection of the user agent, when they request the page.

C. Mainstreaming the mobile learning

Mobile technologies can support and enable teaching and learning, but there is no guarantee that learning will occur. For long term success of m-learning it is necessary to address the majority of students, and to make the content reusable. The solutions have to rely on existing free or low cost, and feasible technologies.

M-learning requires a client platform that is available to most learners anywhere and anytime. This excludes PDAs, iPods, and similar devices. [3]. However, we expect almost all students to own a mobile phone that uses Java MIDP (Mobile Information Device Profile) software and sends and receives IP data traffic.

M-learning works best as a part of blend [4]. Blended learning itself is a way of combining different educational methods, types of content delivery and variety of communication channels (Figure 2). For the normalization of mobile phones into the curriculum, educators need an easy way of quickly and cheaply constructing course materials. This is available through the use of modern software systems for e-education like Learning Management Systems and Virtual Learning Environments.[5] It is natural to try mixing the m-learning into this proven blend by customization of these platforms. These software systems have standardized forms of learning materials that makes them reusable [6].

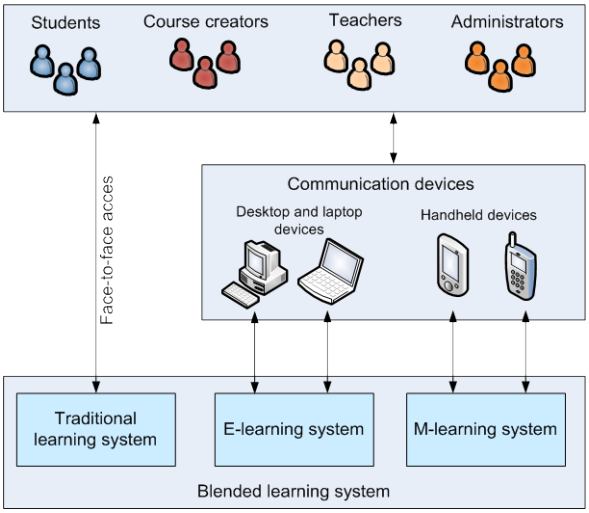

Figure 2 Access to the blended learning system

3. MODEL FOR BLENDING M-LEARNING INTO E-LEARNING

In the previous period in the area of mobile learning there have been many researches, mainly focused on recommendations for mainstreaming the mobile education (Keegen [1], Doering [3]), theory of m-learning and pedagogical models (Sharples, et al. [7],[8]) or methodology for developing m-learning applications (Millard, et al. [9]). Many recommendations and conclusions from these researches can be applied when introducing m-learning system, but there may also appear many problems. Basic criticisms of the past researches can be summarized through following:

- These researches are primarily directed towards communication of participants in educational process, informing and summaries, rather than educational materials delivery, learning or assessment.[10]
- In those cases where delivery of educational materials and assessment was primary goal, mostly rich content capable devices were used, without taking into concern what capabilities of content presentation are common for the majority of students' devices.
- The systems for m-learning considered were mostly viewed as stand-alone systems, without intention of blending them into existing e-learning systems.
- There is no evaluated methodology for introducing m-learning systems and their integration with existing e-learning systems; existing models are technology dependant.
- The efforts to integrate m-learning into LMSs usually fail because of fast development of LMSs and incompatibility of m-learning applications with their newer versions.

Taking into account recommendations published by leading researchers in the field of m-education, we have proposed a model for introducing m-learning into the e-learning system at the Faculty of Organizational Sciences. (Figure 3.)

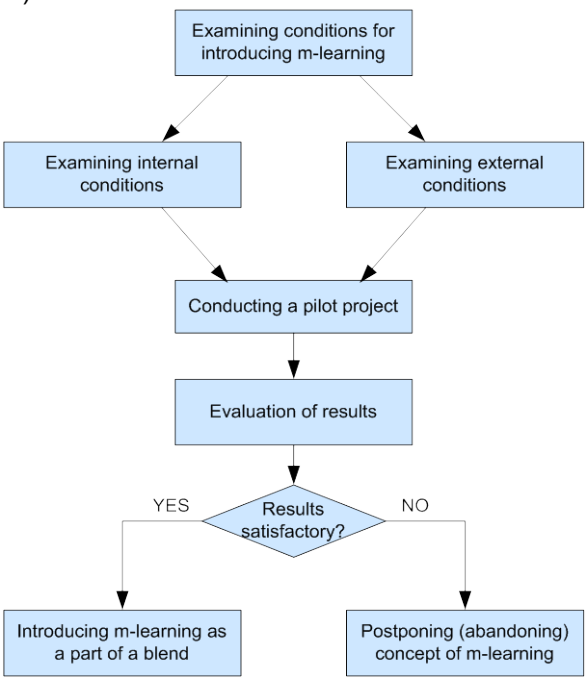

Figure 3 Model for introducing m-learning

Basic requirement for introducing m-learning as a part of a blend is the existence of stable and fully operating system of e-learning. This includes conditions of:

- Internal environment – are there available human resources and technical equipment within existing e-learning system?
- External environment – do students posses adequate knowledge and infrastructure to use m-learning?

After examining conditions for introducing m-learning as a part of a blend, a pilot project will be conducted. The students will be assigned some mobile activities as a part of their learning process.

Data collected during pilot project will be analyzed in order to conclude if it is possible to effectively blend m-learning into the existing e-learning system. We expect to get conclusions about which types of activities, types of learning materials and tempo are best suited for this purpose.

Finally, conclusions will lead either to postponing implementation of m-learning as a part of system for e-learning, or to introducing it for certain types of activities as a standard part of blended learning system.

4. EXAMINING THE CONDITIONS FOR INTEGRATING M-LEARNING INTO E-LEARNING SYSTEM

Technical conditions for integrating m-learning into e-learning systems include adequate infrastructure in educational institutions, available skilled personnel and possession of mobile devices among students.

D. Prerequisites for blending m within e – internal environment

In the Laboratory for e-business, Faculty of Organizational Sciences, many undergraduate and postgraduate blended courses have been conducted for several years. The Laboratory is equipped with necessary technical infrastructure and there are available, qualified and experienced human resources.

The system for e-learning in the Laboratory for e-business is based on SME server v7. Web server hosts learning management system Moodle. About 700 postgraduate and undergraduate students of the Faculty of Organizational Sciences get their yearly tuition through the e-learning system. Skillful and experienced teaching and administration personnel are involved in creating, maintaining and teaching more than 40 online courses.

We derive the conclusion that necessary internal environment conditions are present.

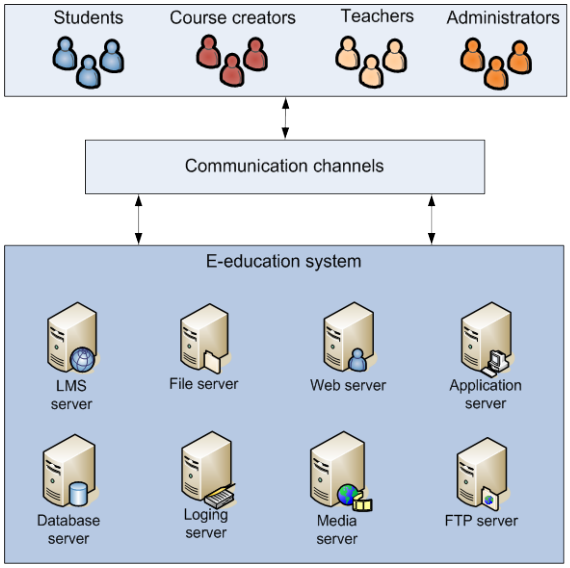

Figure 4 Infrastructure of e-education system

E. Prerequisites for blending m within e – external environment

In order to determine students' possibilities for using mobile content and activities in learning process, we have conducted a survey. Goal of the survey was to determine:

- type of devices that students own and technologies supported by these devices
- experience and habits of using WAP services and mobile Internet
- the use of additional features of the cell phones, such as calendar, e-mail, audio, video and textual notes

We created a questionnaire divided into several groups of questions. First group of questions was created to determine type of device that is most commonly used by students at our Faculty.

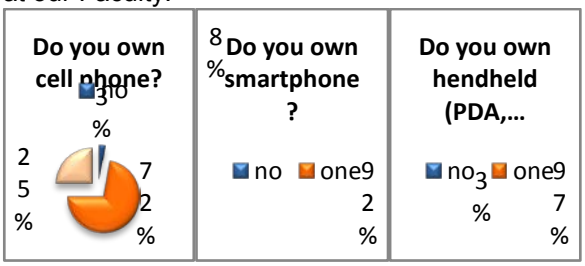

Figure 5 Ownership of mobile devices

The results show that more than 97% of students own mobile phone, while smartphone or handheld own less than 8% of students (Figure 5).

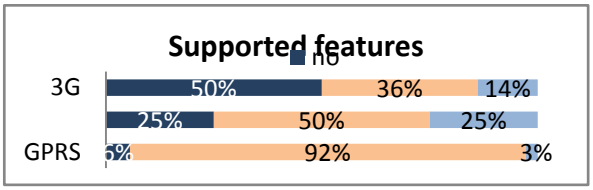

Figure 6 Supported features

When analyzing features supported on students' mobile devices, we could see that more than 92% of devices supported GPRS. Students answered that only about 50% of devices supported Java, while about 25% did not know this data. Further, objective analysis of models they have stated to own, showed that Java is supported on about 86% of devices and GPRS on 96%. 3G features are supported on about 36% of students' devices.

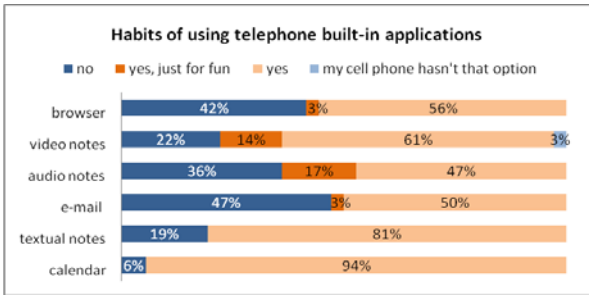

Figure 7 Habits of using built-in applications

Most frequently used application is calendar (94%), followed with textual (81%) and video

notes (75%). Audio notes (64%), browser (59%) and e-mail (53%) are less frequently used, but still majority of the students had experience of using these applications on their cell phones.

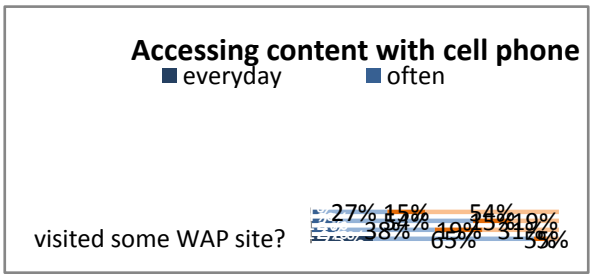

Figure 8 Experience with different types of wap content

When looking into details about different wap browsing/downloading experience we could see that actually about 95% of students had mobile browsing experience, but that only 25% are everyday users. Pictures are most downloaded content (81% of examinees had experience with it), followed by music (69%) and video (46%).

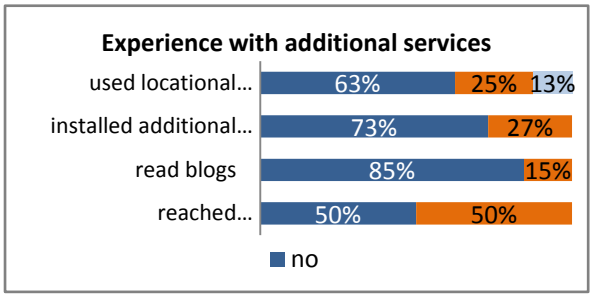

Figure 9 Students' experience with m-services

Additional services use only about one quarter of population. However, it is interesting that even 50% of students have already accessed learning materials on their phones.

The most important conclusion from this survey was that GPRS and Java technologies are widely present on students' devices, and that they can be used as target technologies for delivering mobile content for m-learning. Educational content should be customized for the use on cell phones, not only smartphones and PDAs.

It is also important that significant number of students is not aware of possibilities of their devices and is not used to mobile browsing. In order to effectively blend m-learning into e-learning, some students will have to be given some training in using their mobile devices for learning purposes.

5. THE PILOT PROJECT

Not all activities and teaching materials used in e-learning system are suitable for mobile delivery. Before allowing students to access one of their learning activities via mobile device, some consideration have to be made.

F. Moodle Activities

Moodle allows a teacher to create many versatile activities. Most frequently used activities are Assignments, Quizzes, Forums, Resources, Lessons and Choices. For the pilot project it was necessary to analyze constraints of these activities and choose most suitable one for mobile delivery. Table 2 shows most frequently used Moodle activities, considerations and constraints for delivery on mobile phone for each activity.

Table 2 Moodle activities and mobile delivery

Moodle activity	Suitability for mobile delivery	Considerations/constraints
Forum	Yes	Constraint: slow input
Assignment – online text	Yes	Suitable only for short submissions
Assignment – upload file	Yes	Only for uploading audio or image files created on the mobile device; it is better to use it as a desktop activity
Chat	Yes	Constraint: slow input
Glossary	Yes	Constraint: slow input
Workshop	No	-
Quiz	Yes	Not all types of questions are suitable
Choice	Yes	Very simple, no constraints
Lesson	Yes	Only for small text lessons, without multimedia content

Among all activities, we have chosen to implement quizzes for the mobile delivery in pilot project, for the following reasons:

1) The content and format that is presented in quizzes can be controlled best.
2) Quizzes have proven value either as self assessment or as a method of collecting information on students' knowledge.
3) Quizzes are widely used in existing e-learning environment and have big impact on students' final grade.

Pilot project consisted of two experimental mobile quizzes, and inquiry on the immediate experience. For the purposes of mobile quiz assessment we created an application blended into Moodle. Moodle (Modular Object-Oriented Dynamic Learning Environment) is one of the most frequently used learning management systems (LMS) for organizing and carrying out e-learning courses. It is open-source, web-oriented, user-friendly platform for online learning.

G. The Mobile Quiz Application Blended into Moodle

Moodle is written in PHP. It used to rely merely on MySQL database. Moodle API is present from the version 1.7. It enables uniform database access for different DBMSs.

Mobile quiz application is written in PHP, based on Moodle API. For its mobile delivery it uses XHTML MP. It can be accessed from the mobile telephone default browsers, and from Opera Mini, which is favorite free mobile browser. Opera Mini is JAVA application and can be installed on any cellular telephone that supports JAVA MIDP.

The application is based on server side customization of pages for mobile delivery.

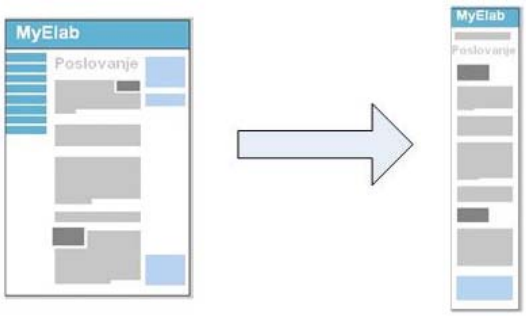

Figure 10 Desktop version of the web page and web page optimized for the mobile device

Desktop Moodle presents the course content in 3 columns. The auxiliary blocks are positioned on both sides of the screen, while the main course content is presented in the center of the screen. Mobile applications generally present content in one column wide exactly as the screen, so that there is no need for horizontal scrolling. Mobile Moodle Quiz application does the same. Auxiliary blocks are collapsed to necessary links. The application was developed using Larman methodology. Use case diagram is shown in Figure 11.

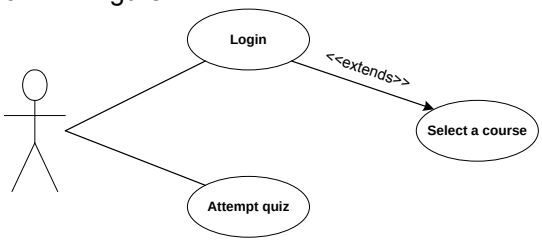

Figure 11 Use cases for the Mobile Moodle Quizzes Application

The Use Cases for the mobile application are

1. Login
2. Select a course
3. Attempt quiz

Login use case

Student activates the application. The System checks the student device and redirects it to the mobile application. The Student fills in his username and password and calls the system to log him in. The System checks the provided data and shows the available quizzes in the course, or the available courses, if the student is enrolled to more than one course.

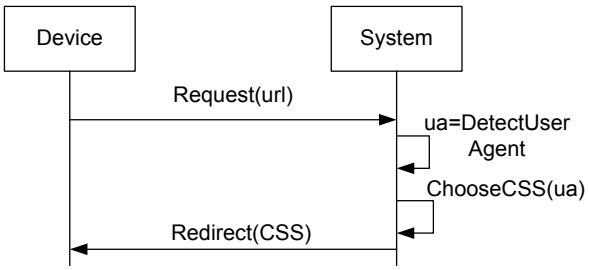

Figure 12 A fragments from the login UC explaining the adaptation of content.

During the login UC the application uses WURFL (Wireless Universal Resource File) to get the user agent header and to detect the device, redirects the user to the correct version, and decides which WCSS theme to select from 3 themes that we have created for different mobile user agent presentation capabilities.

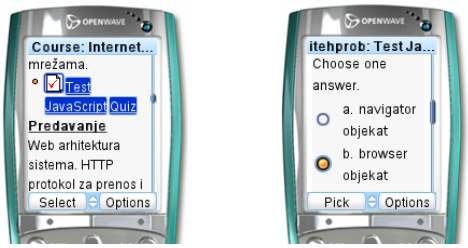

Figure 13 Main course mobile page and Quiz question mobile page

H. Evaluation of the pilot

Survey on the usage of mobile quizzes application included mobile students' assessment and a questionnaire.

First quiz had five questions of different types (matching, multiple answer, yes-no, short answer), about the organizational aspects of their undergone E-Business subject. Students were well informed about that matter. The aim of this introductory quiz was to get students acquainted with the question types' interface, and loose the pressure or fear from mistakes. The following questionnaire examined the usage of new media, clarity of interface, and adequacy of appearance as well as the impressions about difference from desktop approach. The second quiz was on the matter from the E-Business course. Similar ten-questioned quizzes these students had to pass during the semester, through Moodle, only this time without the usual 10 minutes time limit. After the quiz the students were again asked about the interface, if they got used to it, some questions about fatigue and distractions while taking the quiz.

It took on average 234.2 seconds to finish the first quiz. That is 3 minutes and 54 seconds, 46.84 seconds per question on average. We have compared the results and time taken with the introductory quiz the students did on E-business course on their desktop computers.

Table 3: Average time taken and average scores on two mobile quizzes and control, desktop quiz

	total time	number of questions	time per question (sec)	average score (%)
first mobile quiz	3 min 54 sec	5	46.84	78.68
second mobile quiz	6 min 58 sec	10	41.79	37.01
desktop quiz	5 min 33 sec	10	33.27	83.80

Attempting that introductory 10 questioned quiz lasted on average 332.67 seconds or 5 minutes and 33 seconds, 33.27 seconds per question on average. The obvious time difference per question (40%) is due to the longer loading of the (smaller sized) pages. Some additional time could have been taken for reading the question text. The average time per question on the second mobile quiz was shorter 41.79 sec per question. It can be explained by the fact that students got used to the interface and new medium, but also with giving up from answering. It can be concluded, with the average score of 37.01%, that the tested students were not prepared and that the questions were difficult.

The majority (58%) of the students had affirmative opinion about mobile quizzes. 17% answered that they liked it, 42% found it interesting, 8% unusual, and 33% gave negative answer (somewhat exhausting). No one chose the answer boring.

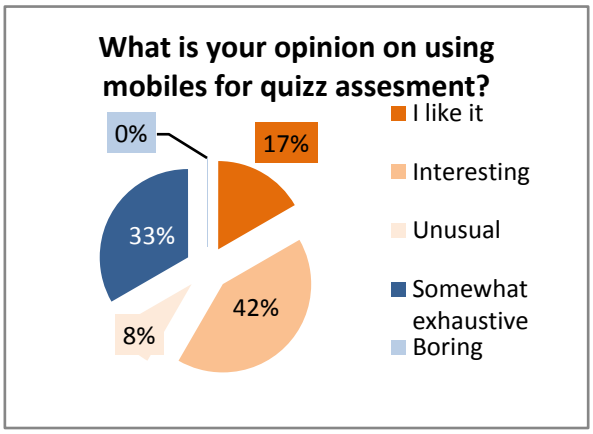

Figure 14 Students' impression on mobile quizzes

Comparing to the appearance of the other question types multiple answers has lower position on the chart. This fact leads to the conclusion that WCSS for this type of questions should be changed by using smaller fonts, so that more text fits into the screen. Short answer type of question, on the other side got a little bit better grade than the other types, probably because its form resembles SMS that are cell phone users accustomed to.

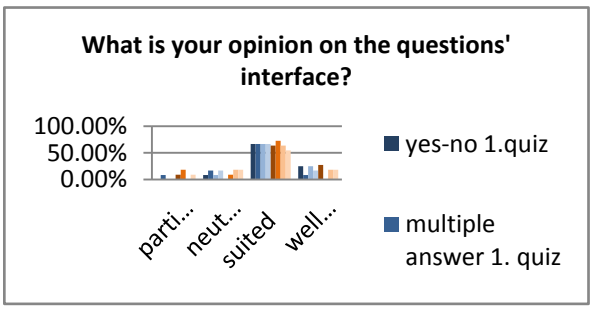

Figure 15 Opinion on the questions' interface

The usage of the application depends on the easiness of continuous usage. Therefore the examinees were asked if they sensed fatigue. After 11 minutes of assessment some of the examinees felt tired to some extent (overall fatigue about 30%), especially when the eyes are concerned (about 40%).

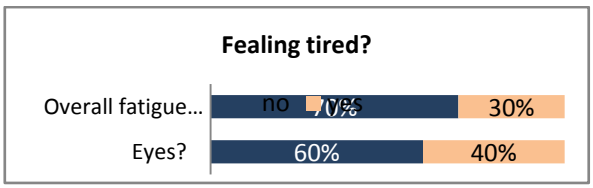

Figure 16 Fatigue during mobile quizzes

6. FUTURE WORK

Previous results suggest that the best usage of mobile tests and mobile learning is with short forms that are similar to the everyday usage of mobile phones. Positive impression that mobile testing has left over the examinees leads to the conclusion that this type of learning activities would be welcomed in the blend of e-learning and other learning activities, for raising motivation, and as a useful media. We expect that it would raise efficiency and effectiveness of e-learning systems. Cost-benefit analysis should be performed in order to determine the exploitation costs of the system, since it includes third party – mobile providers. From the aspect of education we expect long term success of the integration if we carefully perform following steps:

- Some students should be given prior training of more advanced usage of the devices they already possess.
- Evaluation of mobile quizzes should be done on regular subject matter, not just on example tests.
- Planning and preparation of content for mobile learning.
- The effect comparing to the matter learned more traditionally has to be measured, as well as
- How often and why is mobile approach chosen rather than desktop if it is not mandatory?
- Possibilities of web based usage of audio and video formats that are already supported by GPRS enabled phones have to be thoroughly examined in the context of Moodle activities.
- Adaptation of other Moodle activities to mobile delivery has to be performed.
- SMS learning activities – forms that resemble SMS could be used for collecting opinions, impressions, and ideas.
- MMS activities - it is desirable to include, because of easier usage, besides textual, other types of materials; for instance, MMS for collecting audio and video clips with answers or opinions on particular topics.
- Mobile learning should include edutainment and JAVA applications.
- Mobile learning should be in short forms that resemble everyday usage of mobile phones.
- For the beginning mobile learning activities should be built more on text than on multimedia while in general students gain better devices.

7. CONCLUSION

Mobile learning concepts are presented in this paper. We have described the aspects of mainstreaming of learning and the implications on usage of target devices. Blending of m-learning within the systems for e-learning was described as best practice. The research was divided into three parts. The circumstances under which students use mobile phones were examined and target technology was chosen. Moodle API based mobile learning application was designed for the purposes of research. The evaluation of system was done and conclusions were made. The research suggests that students willingly accept mobile learning activities, but that frequency of mobile usage, type and lasting of the activities should be carefully chosen. This leads us to further research on these particular topics. Finally, the quality of mobile learned matter should be compared to the quality of one accepted more traditionally.

Fast development of mobile technology will certainly bring new, powerful devices with prices affordable to the majority of population. Current models already offer enough possibilities, with built in cameras, audio and video capturing, data transmission and decent textual interface, to be used for creative multimedia education.

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