User-centered Design of m-Learning System: Moodle On The Go

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In order to truly integrate e-Learning system into regular curriculum at a university, mobile access to Learning Management Systems has to be enabled. Mobile devices have the potential to be integrated into the classroom, because they contain unique characteristics such as portability, social interactivity, context sensitivity, connectivity and individuality. Adoption of Learning Management Systems by students is still on the low rate, mostly because of poor usability of existing e-Learning systems. Our initial research has confirmed this hypothesis. Usability issue is rising to the higher level on the mobile platform, because of the mobile devices' limited screen size, input interfaces and bandwidth, and also because of the context of use. Our second hypothesis was that it is wrong to consider a mobile device as a surrogate for desktop or laptop personal computer (PC). By just adopting the existing Learning Management System on mobile devices with adaptive technologies such as Google proxy, we do not acquire the satisfactory results. Usability can prove to be even lower compared to desktop application. One possible solution to the problem could be development of rich client applications for today's mobile devices that would raise the usability to a higher level. We developed a PocketPC

prototype application by using user-centered design principles, which we presented as a third alternative in usability research conducted among university students. Results gathered in such a way have confirmed that the development of e-Learning systems, in order to be widely accepted by students, needs to have the user (student) in the center of development process.

Categories and Subject Descriptors: H.5.2 [**User Interfaces**]: User-Centered Design, Benchmarking, Evaluation/Methodology, Input Devices and Strategies, Interaction Styles General Terms: Design, Human Factors, Performance

Additional Key Words and Phrases: Usability, User-Centered Design, M-learning, Moodle, Mobile Devices

1. INTRODUCTION

Education is an organized process of transfer of knowledge, skills, values and beliefs and a prerequisite for any improvement at individual or social level. Owing to technological advances, new opportunities emerge to fulfill the process of education amongst which the strongest representative is the computer, which with its abilities added a whole new dimension to the education process. E-learning is an approach to facilitate and enhance learning through both computer and communications technology. This type of learning uses a network, which can be the Internet, a university network or a corporate computer network.

E-learning is usually based on Learning Management Systems (LMS). LMS is a software that helps in different types of direct and indirect interaction between professors and students, and the exchange of different types of electronic learning material. Most used LMS are Blackboard, WebCT (commercial software) and Moodle (free open source software).

In order to truly integrate e-Learning system into regular curriculum at the university level, mobile access to LMS has to be enabled. Mobile devices have the potential to be integrated into the classroom, because they contain unique characteristics such as portability, social interactivity, context sensitivity, connectivity and individuality. But student experience is not always good, and adoption of LMS by students is still on the low rate. This is mostly because of poor usability.

The prime assumption of this work is that poor usability of existing e-Learning systems leads to poor adoption. Our second hypothesis is that it is wrong to think of a mobile device as a surrogate for desktop or laptop personal computer (PC). By just adopting the existing LMS on mobile devices with adaptive technologies such as Google proxy, we do not acquire the satisfactory results. Usability can prove to be even lower compared to desktop application.

This paper is aimed at issues of LMS systems usability for desktop platform as well as mobile devices. Those issues are addressed to in Section 2 of this paper. Existing research in this field is a focus of Section 3. As a competitive technology for our usability study we developed a prototype that we present in Section 4. Above-mentioned usability study as well as results are presented and discussed in Section 5. Conclusion is given at the end of the paper.

2. USABILITY ISSUE OF E-LEARNING SYSTEMS

As a part of our teaching activities, our faculty is using Moodle LMS in order to support course activities. Professors are usually adding contents for a course, on a

is a subject of test, we also required a comparison technology for adaptive mobile solution. Recently, there are several projects in development that target the use of Moodle on mobile devices through rich client applications. Some of them focus on developing specific modules [Alier 2007] while others aim for full functionality [Internet 2009a; 2009b]. We decided to develop a rich client application for PocketPC, and a web service as a standard middleware interface between Moodle database and a client application. System architecture is shown in Figure 1.

Since Moodle was developed using PHP/MySQL platform, we have chosen to develop a Web Service as more universal data source to access Moodle from different kinds of devices and platforms. Because Web Service implements standard interface described by WSDL (Web services description language), accessible via SOAP (Simple Object Access Protocol) based on XML, it is very well suited as a universal data source, much better than just a MySQL database. It also supports additional features, such as using a firewall for extensive security without additional reconfiguring. In our architecture, Web Service is very important, in order to develop clients and support broad range of mobile devices (PDAs, mobile phones, smart phones, etc.).

Class model for developed prototype is shown in Figure 2. WebService class provides

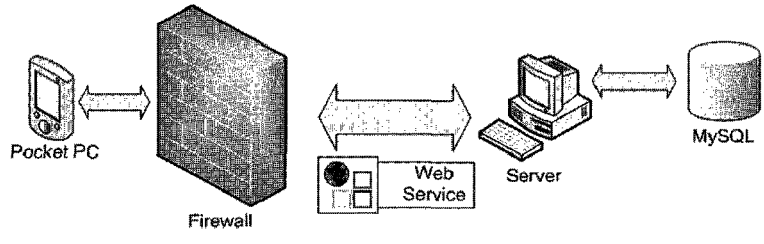

Figure 1. Mobile Moodle Architecture.

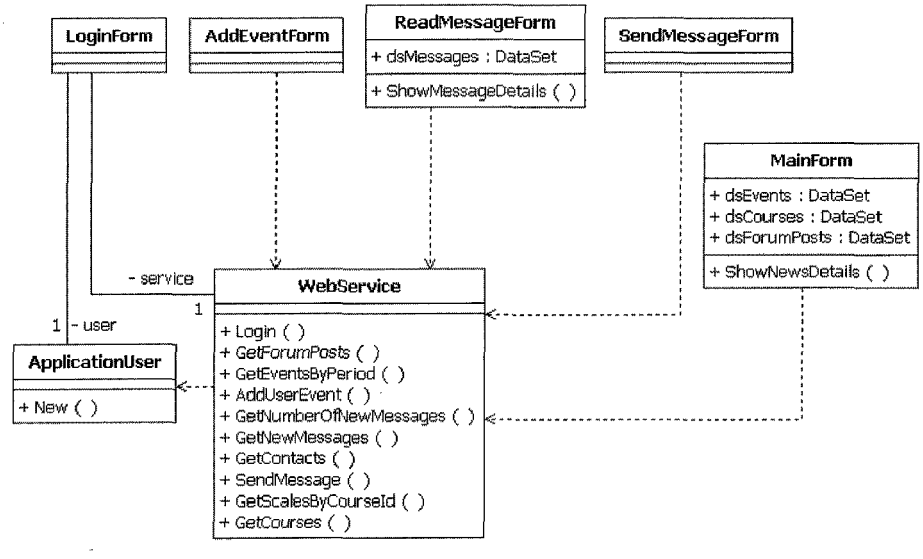

Figure 2. Mobile Moodle Class Model.

methods for access to Moodle back-end system. ApplicationUser class represents the user of mobile Moodle application, which should be authorized via LoginForm. Forms, such as AddEventForm, ReadMessageForm, SendMessageForm and MainForm, represent the user interface of mobile Moodle Application.

Rich client application could be a better solution than standard or WAP Moodle pages, because it targets the main drawbacks (listed in previous section) of these solutions. However, there are downsides to using rich client (fat client) where most significant is forking (Certain changes to Moodle will require updates of client as well as server). The ways of overcoming the disadvantages of mobile devices using our solution are listed below.

4.1 Limited Screen Size

Standard PocketPC screen has QVGA (Quarter Video Graphics Array) resolution, which is 320×240 pixels. To efficiently utilize this space, rich client application is a better solution, because it uses controls designed for this screen size, which are layered on the screen in a way which is more productive and easier to use for end users. We use Tab control to split contents related to different Moodle modules which makes navigation very easy; only one tap (touch screen with a stylus pen) is required for this (see Figure 3). When we need to show list, we use list box control, which enable users to scroll only that area, not the entire screen.

4.2 Limited Input Methods

Standard PocketPC devices support three ways to input characters: write recognition, letter recognition and virtual keyboard. No one of them can compare with the productivity of standard full-size keyboard, with keys. Fastest way to get user action is by tap, and this should be used as much as possible. We should always offer

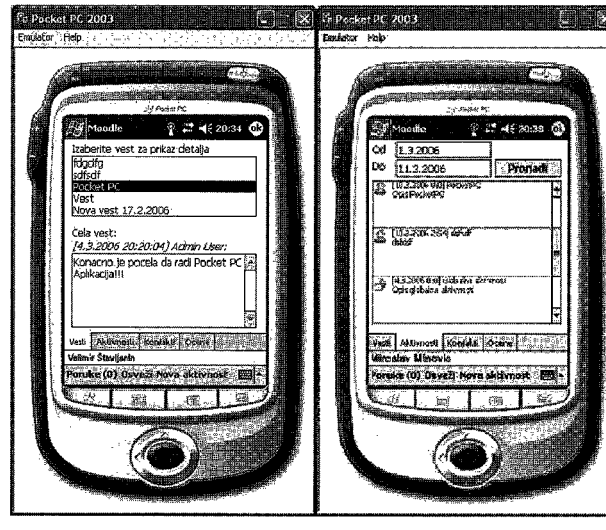

Figure 3. News Module (List and Detail) and Activity Module (list of Activities Between Chosen Dates).

Table I. Comparison of HTML, WAP and Rich Client Moodle Access

	HTML/WML Moodle	Rich client Moodle
Limited screen size	HTML controls, one page model harder to use	Better component layout easier to use
Limited input methods	Each user action requires response from the server, over the network slower and less productive	Richer user controls gives more options for a faster and more productive user interaction
Limited network bandwidth	Has network overhead, complete page is reloaded for each data change	Small network overhead, only new/modified data exchanged

predefined data for user to choose, rather than to enter them. Utilizing mobile controls, the rich client Moodle requires less user interaction in order to reach the required content and information.

4.3 Limited Network Bandwidth

Most users use GPRS connection, which has limited bandwidth, and is also expensive when compared to standard home or broadband Internet connections. However, it is well suited for mobile Internet access, but needs to be utilized carefully. Only necessary data should be transferred. Our client application transfers only the required data (for example, only activities between chosen date interval are transferred; only details for chosen news), and performs cashing of such data locally, where any repeated request for the same data will just check for new or modified data to be retrieved via Web Service (already opened news does not require network access, can be viewed off-line).

Brief comparison between existing solutions and prototype application by selected criteria is given in Table I.

A brief comparison showed competitive advantages of customized smart client application over HTML/WML-based solution. Based on that, we proceeded with the usability study, which includes examination of different usability aspects such as stability, response and feedback, consistency, control and screen design.

5. USABILITY OF MOODLE SYSTEM

Usability often refers to the question of how well users can use system functionality [Nielsen 1993]. Usability is not a one-dimensional property of user interface. It is associated with five attributes: learnability, efficiency, memorability, errors and satisfaction. In order to measure usability we conducted a think-aloud study [Nielsen 1993] amongst university students.

The goal of the study was to determine the usability of Moodle LMS system. We attempted to determine the quality of our personal digital assistant (PDA) application prototype in comparison to other available technologies for using Moodle via mobile devices and also to compare the results to standard desktop approach using web browser. As an alternative technology we have chosen the Google Proxy (Figure 4) for mobile devices that provides the service of reformatting the requested content to make it more suitable for mobile devices. We used Google Proxy for both mobile phone and PDA.

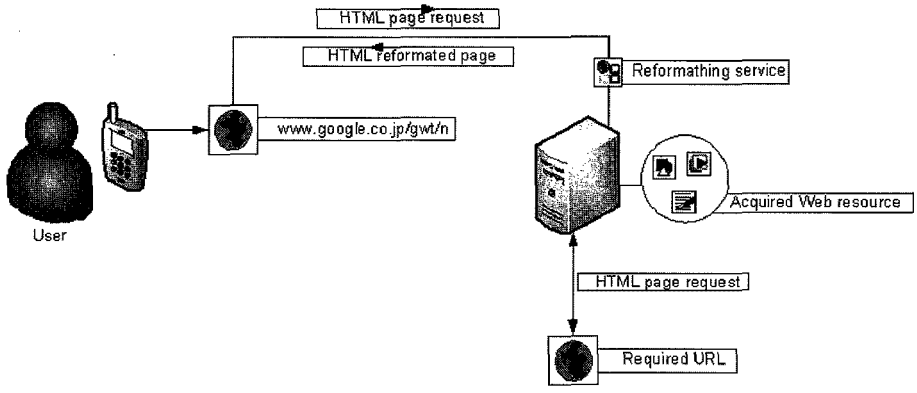

Figure 4. Google Proxy Architecture.

Table II. Click or Tap Numbers.

Device	HP Ipaq rx3715	Dell Axim X30	Nokia, N80	QTEK, 9100
Type	PDA	PDA	Smart Phone	Smart Phone
Operating System	Pocket PC 2003	Pocket PC 2003	Symbian OS 9.1	Windows Mobile 5
Screen				
Colors	65536 scales	16-bit (64K colors)	256K colors	65K colors
Size	3.5 in.	3.5 in.	2.1 in., 35×41 mm	2.8 in., 42×57 mm
Resolution (pixels)	320×240	320×240	352×416	320×240
Memory				
ROM	128 MB	64 MB	64 MB	128 MB
RAM	64 MB	64 MB	64 MB	64 MB
Processor	Samsung S3C2440, 400 MHz	Intel 624 MHz Xscale	Dual ARM 9 220 MHz processor	TI OMAP 850200 MHz processor
Input device	Touchscreen/ stylus pen	Touchscreen/ stylus pen	Phone numerical keyboard	Touchscreen/stylus pen, Built-in full QWERTY key-board
Network	WiFi, Bluetooth	WiFi, BlueTooth	WiFi, BlueTooth, GPRS, EDGE, 3G	WiFi, BlueTooth, GPRS, EDGE

Our research was conducted on one desktop PC, two PDA devices and two mobile phones. First PDA was HP Ipaq rx3715, with our rich client prototype. Second was Dell Axim X30, that subjects used for performing tasks on Google Proxy reformatted content. Both devices had Pocket PC 2003 for an operating system. Finally, our mobile phone devices were Nokia, model N80 with Symbian OS 9.1 and a slider numerical keyboard and QTEK, model 9100 with Windows Mobile 5, touch screen and a slider QWERTY keyboard. A more detailed account of characteristics of each device is given in Table II.

Students first performed a predefined set of tasks on a desktop computer using web browser. Then they performed the same predefined set of tasks first on PDA using our

custom PDA Application, then on PDA using internet browser through Google Proxy, and at the end on mobile device using internet browser through Google Proxy. The tasks were done in a predefined order:

1. First they had to log in.
2. Then they were expected to check for news and then read them.
3. Next came checking for the upcoming activities and informing on them.
4. Then, they needed to send a message to other participants as well as check their own messages.
5. Finally they were required to check their grades on different courses.

After the participants performed a set of tasks on different platforms, they were asked to fill out a questionnaire. The questionnaire included a few demographic questions about respondents and their computer skills; then followed questions about subjective satisfaction on every platform and questions that required them to rate the platforms and to explain their rating. Questions about subjective satisfaction were presented using a seven-point semantic differential rating scale from positive impression to negative impression (for example, 1=complicated to 7=simple). The participants in our research were undergraduate senior year students from different departments at University of Belgrade, Faculty of Organizational Sciences. Research was conducted in laboratory conditions. A total of 12 students participated in the study and all of them completed the end survey (See Appendix I Survey). They were 8 men and 4 women. All respondents were experienced users of computer, PDA and mobile phone. The mean knowledge about CMS systems was 4.92 on the seven-point scale, where 1=no knowledge about CMS systems and 7=sufficient knowledge about CMS systems. On the scale ranging from 1=little experience with e-learning to 7=experienced user of e-learning systems, our participants' mean was 4.58, with no answer under 3.

Students performed the tasks while sitting down. The proceedings of the study were documented by two cameras, one aimed directly at the students' faces to reveal facial expressions during the session and another aimed at covering the actions on the mobile device. Also a microphone placed on each student recorded the commentary and their voices. During the session, the participants were encouraged to think out loud, by asking them questions such as these: What are your thoughts now?, Can you state your impressions about performing this action? and so on.

During the task, we measured the efficiency of use by measuring the number of clicks/taps and the times necessary to complete the task. Besides efficiency, we measured errors by number and type (simple and catastrophic), and subjective satisfaction.

Table III provides the results of measuring the amount of click/tap actions to complete the given operation with results of measured amount of data transfer in Kb per operation. Operations are processed for each device/technology. The results provided indicate that PDA Application has the lowest amount of click/tap actions compared to other technologies. The only exception is Read Activities. The reason for that is poorly developed input control for specifying the date interval for searching the activities. It does not provide the ability of choosing the date from the calendar but requires manual input. Another indicative point that this is a good place of improving the interface came from our test subject who commented on this feature as inadequate

Table III. Click or Tap Numbers.

	Desktop	PDA Application	PDA Browser	Mobile Browser
Login	15	15	16	24
Read News	2	1	7	12
Read Activities	2	22	9	12
Send Message	17	16	22	29
Receive Message	2	1	5	8
Check Grades	3	1	6	9

Table IV. Measured Data Transfer (Kb).

	Desktop	PDA Application	PDA Browser	Mobile Browser
Login	166	1	37	37
Read News	17	4	13	13
Read Activities	30	1.5	16	16
Send Message	7	1	9	9
Receive Message	6	2	7	7
Check Grades	5	1.5	4	4

during our think-aloud study. Some of these comments were: *The date input is too complicated!* or *It is too difficult to enter the date, and I am repeatedly making a mistake!*.

Data given in Table IV for data transfer clearly states the obvious advantage that PDA Application has over other technologies. Interaction between PDA Application and a Web Service provides impressive amount of savings in data transfer due to the ability of PDA to return only the data relevant for the given operation.

Table V is a summary of results acquired by measuring the time efficiency of each operation executed by our test subjects. The data shown in the table are average times per operation for given devices/technologies. Revision of data leads us to a conclusion that PDA Application is more time efficient than other two mobile technologies for each operation performed. An interesting fact is that it has also proved to be more efficient than standard Desktop use of Moodle except in two cases, Login and Read Activities. Average time for Read Activities can be explained by the

Table V. Average User Time per Operation (Seconds), for Each Device.

	Desktop	PDA Application	PDA Browser	Mobile Browser
Login	27.8	34.7	39	54.3
Read News	58.2	23.2	80.6	87.4
Read Activities	82.6	98.5	121.5	139.9
Send Message	74.8	39	181.6	209
Receive Message	55	27	65.9	57.2
Check Grades	45	18.8	59.6	65.6

poor method of date input mentioned earlier whereas the reason for a longer lasting Login operation could be blamed on the lack of keyboard on PDA's part. Also several of our test subjects positively commented on the ease of use of PDA Application as opposed to the use of desktop internet browser. Some of these comments were *It is a bit confusing to navigate to the wanted section, and it is hard to immediately find a way to perform the given operation*, this regarding the Desktop internet browser, and also *It is much simpler to find my way around on this than on Desktop*, regarding the PDA Application. The results and subject comments lead us to a conclusion that Moodle is not intuitive and user friendly. It is obvious that our subjects had difficulty in performing even the easiest of tasks using this technology.

In order to graphically present the corresponding data we provided the chart (Figure 5). Average time per operation, for our rich client prototype is shown with red vertical bars.

As described, the subjective satisfaction was measured by a seven-point semantic differential rating scale. Questions included in measurement were System is pleasant to use; Interface is complete; Interface is simple for use; System is fast for use; System

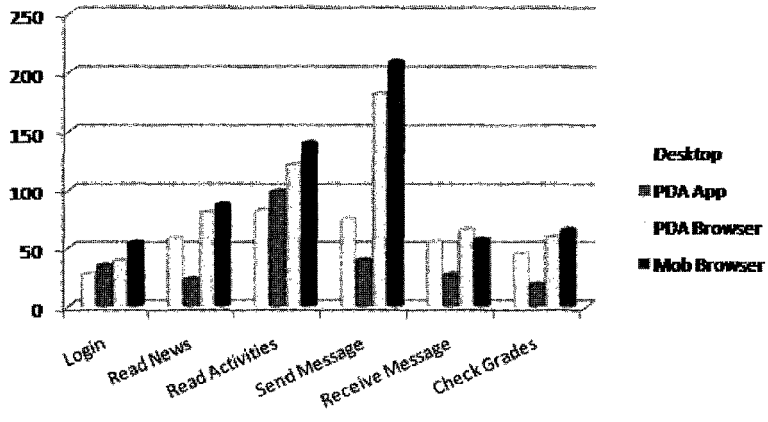

Figure 5. Average User Time per Operation (Seconds), for Each Device.

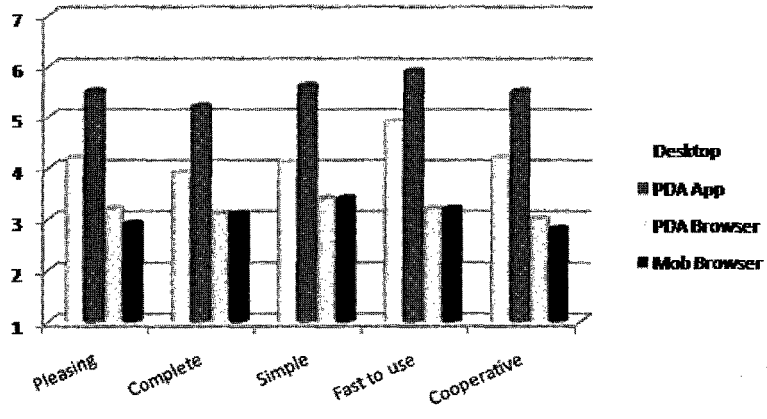

Figure 6. Results Describing Subjective Satisfaction for Each Platform.

is cooperative in completing the tasks. Results are shown on the chart (Figure 6).

Ranking results were similar to results from satisfaction measurement. Almost all respondents (9 of them) said that the most preferred platform is PDA application. Second preferred was desktop, third PDA Browser and fourth mobile browser. Some comments about PDA platform were *PDA application is very easy for use, and almost all poor implementations from desktop are corrected. PDA application is almost perfect! Definitely, PDA application is my most preferred solution.* During the test there were no catastrophic errors, but there were few occurrences of simple errors such as accidental closing of mobile browser (two times) and one network error during the call to a Web service. The test was resumed after the second try.

In spite of the positive results acquired by this research we noticed a few downsides to this type of testing. Primarily, the order of conduct implied the ability of our test subjects to accommodate to the LMSs' way of use. Since they performed the same set of tasks using Desktop, PDA Application, PDA Browser and mobile browser, respectively, they were in position to learn how to perform the same tasks on mobile devices with adaptive technologies. Even so, the results clearly stated that PDA Browser and mobile browser were by far the most complicated tools in order to complete the given tasks. Limited resources provided us with another difficulty during our session. The lack of instruments forced us to form a queue, which caused the need of additionally motivating our subjects. This is also a reason why the optimal amount of test subjects was only 12.

Owing to the mobility of technology tested here, we cannot ignore the effect of using e-Learning system, *On The Go,* which is probably the strongest argument for this type of technology. Next step in our research will be to conduct a study in real-life situation, away from office or classroom, and to consider the usability in such circumstances. Also, we should consider the learning effect achieved this way.

6. CONCLUSIONS

During our experience in working with LMSs we came to a conclusion that users have a problem accommodating to them. Another question that occurred was inability of such systems to adequately provide their services via mobile devices. For that purpose we conducted a usability study that targeted users' ability to accommodate to specific LMS. As an alternative to mobile adaptive technologies for access to specific LMS we developed a rich client prototype for mobile device. Our usability study included this technology as an alternative.

The results and subject comments gathered during our study lead us to a conclusion that Moodle is neither intuitive nor user friendly. It stated as obvious that our subjects had difficulty in performing even the easiest of tasks using desktop technology. Adaptive technologies for accessing Moodle via mobile devices gave even lower results, and proved as inadequate. Our rich client prototype proved to be more time efficient than other two mobile technologies for each operation performed. An interesting fact is that our prototype even preceded desktop approach and was favored by most of the subjects. Further development may include implementation of other popular Moodle modules (like blog, wikis, quiz, Hot Potatoes quiz, lessons, assignments etc.). However, we should carefully weigh the benefits before deciding to implement

support for other Moodle modules in rich client application, because of mobile device limitations (e.g. screen size, memory, keyboard etc.). Not all of them are well suited to be used from a mobile device.

As a continuation of our research we will focus on the usability of LMS systems in real-life situation, during the class and also away from office or classroom, through the use of mobile devices.

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REFERENCES

ALIER, M., P. CASADO, AND M. J. CASANY. 2007. A mobile extension of a web based moodle virtual classroom. In *Proceedings of the e-Challenges Conference (e-Challenges 07).*

BAR, H., G. HAUSSGE, AND G. ROSLING. 2007. An integrated system for interaction support in lectures. In *Proceedings of ITiCSE07.*

BEALE, R. 2005a. Mobile blogging: supporting informal mobile learning. In *Proceedings of MLEARN 2005.*

BEALE, R. 2005b. Supporting social interaction with smart phones. *PERVASIVEcomputing.*

BLACK, J. T. AND L. W. HAWKES. 2006. A prototype interface for collaborative mobile learning. In *IWCMC06.*

BODN, J., J. K. L. M. W. C. W. M. 2007. Point or click? In *Proceedings of Second International Conference on Internet and Web Applications and Services ICIW'07.*

CHATTI, M. A., S. SRIRAMA, D. KENSCHE, AND Y. CAO. 2006. Web services for collaborative learning. In *Proceedings of Fourth IEEE International Workshop on Wireless, Mobile and Ubiquitous Technology in Education ICHIT'06.*

CORRADI, A., R. MONTANARI, AND A. TONINELLI. 2007. Adaptive semantic middleware for mobile environments. *Journal of Networks 2,* 1.

COSTABILE, M. F., A. DE ANGELI, R. LANZILOTTI, C. ARDITO, P. BUONO, AND T. PEDERSON. 2008. Explore! possibilities and challenges of mobile learning. In *Proceedings of CHI 2008.*

COUNTS, S., H. T. HOFTE, AND I. SMITH. 2006. Mobile social software: Realizing potential, managing risks. In *Proceedings of CHI 2006.*

HOUSER, C. AND KINJO, THORNTON, P. 2005. Poodle: a course-management system for mobile phones. In *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'05).* 211– 215.

INTERNET. 2009a. Mobile moodle. http://www.mobilemoodle.org/momo18/.

INTERNET. 2009b. Moodle on mobile phones. http://trinetra.ncb.ernet.in/placements/Contents/TermPaper/MoodleonMobilePhones.pdf.

KRAMER, B. J. AND G. STROHLEIN. 2006. Exploring the use of cellular phones for pervasive elearning. In *Proceedings of Fourth Annual IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOMW'06).* 190–195.

LEWISCARR. 2009. Moodle for windows mobile. http://lewiscarr.co.uk/node/32.

MELTON, J. 2006. The lms moodle: A usability evaluation. *Languages Issues 1,* 11, 1–24.

MILOVANOVIC, M., M. MINOVIC, M. LAZOVIC, AND D. STARCEVIC. 2009. Mobile educative game: case study of adventure. In *Proceedings of 11th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI) 2009.*

NIELSEN, J. 1993. *Usability Engineering.* Morgan Kaufman, San Francisco, CA, USA.

OBRENOVIC, Z., J. ABASCAL, AND D. STARCEVIC. 2007. Universal accessibility as a multimodal design issue. *Communications of the ACM 50,* 5, 83–88.

OBRENOVIC, Z. AND D. STARCEVIC. 2004. Modeling multimodal human-computer interaction. *IEEE*

Computer 37, 9, 62–69.

PANTOVIC, V., D. STARCEVIC, AND M. SAVKOVIC. 2006a. The role of portal technologies in corporate lifelong learning system. In *Proceedings of the CATE 2006.*

PANTOVIC, V., D. STARCEVIC, AND M. SAVKOVIC. 2006b. Virtual business school of energoprojekt group. In *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2006.* 833–838.

SAVOLAINEN, O. 2009. Moodle user experience. http://www.pilpi.net/software/moodle/.

SEONG, D. 2006. Usability guidelines for designing mobile learning portals. In *Proceedings of The 3rd Interna- tional Conference on Mobile Technology, Applications and Systems - Mobility 06.*

SHARPLES, M., D. CORLETT, AND O. WESTMANCOTT. 2002. The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing 6*, 3, 220–234.

YINGLING, M. 2006. Mobile moodle. *Journal of Computing Sciences in Colleges 21*, 6, 280–281.

ZHANG, Y., S. ZHANG, S. VUONG, AND K. MALIK. 2006. Mobile learning with bluetooth-based e-learning system. In *Proceedings of IWCMC06.*

APPENDIX I SURVEY

1. Sex M F
2. Age
3. Are you (1 corresponds to the state on the left side, 7 corresponds to the state on the right side):

Novice computer user	1 2 3 4 5 6 7	Computer expert
No experience with e-Learning systems	1 2 3 4 5 6 7	Experienced user of e-Learning systems
I have no knowledge in e-Learning systems	1 2 3 4 5 6 7	I have sufficient knowledge in e-Learning systems

4. By choosing one number state your impressions on the given technology (1 corresponds to the state on the left side, 7 corresponds to the state on the right side).

a) Desktop platform

Pleasant to use	1 2 3 4 5 6 7	Unpleasant to use
Interface is complete	1 2 3 4 5 6 7	Interface is incomplete
Interface is simple for use	1 2 3 4 5 6 7	Interface is complicated for use
Interface is fast for use	1 2 3 4 5 6 7	Interface is slow for use
System is cooperative in completing tasks	1 2 3 4 5 6 7	System is non-cooperative in completing tasks

b) PDA rich client application

Pleasant to use	1 2 3 4 5 6 7	Unpleasant to use
Interface is complete	1 2 3 4 5 6 7	Interface is incomplete
Interface is simple for use	1 2 3 4 5 6 7	Interface is complicated for use
Interface is fast for use	1 2 3 4 5 6 7	Interface is slow for use
System is cooperative in completing tasks	1 2 3 4 5 6 7	Systemis non-cooperative

c) PDA Browser

Pleasant to use	1 2 3 4 5 6 7	Unpleasant to use
Interface is complete	1 2 3 4 5 6 7	Interface is incomplete
Interface is simple for use	1 2 3 4 5 6 7	Interface is complicated for use
Interface is fast for use	1 2 3 4 5 6 7	Interface is slow for use
System is cooperative in completing tasks	1 2 3 4 5 6 7	System is non-cooperative

d) Mobile phone browser

Pleasant to use	1 2 3 4 5 6 7	Unpleasant to use
Interface is complete	1 2 3 4 5 6 7	Interface is incomplete
Interface is simple for use	1 2 3 4 5 6 7	Interface is complicated for use
Interface is fast for use	1 2 3 4 5 6 7	Interface is slow for use
System is cooperative in completing tasks	1 2 3 4 5 6 7	System is non-cooperative

Rank solutions according to personal impressions (1 to 4):
a) Desktop platform
b) PDA rich client application c) PDA Browser
d) Mobile phone browser
Comment on your choice:

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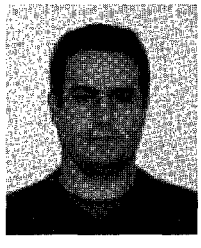

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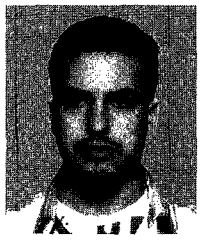

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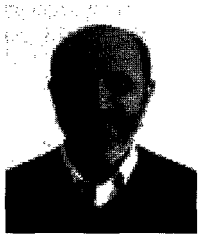

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