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
weekly basis. Students are provided with the ability to regularly inform on new events and gain new information on course via News section on our e-Learning portal. Collaboration, as well as discussion is encouraged through forums. Quiz module is ideally used for student self-examination during the semester, and also for student knowledge evaluation. In spite of the obvious upsides of this type of conducting course, students bring several issues of use to our attention. We constantly receive e-mails, with questions about finding some material, logging-in to the system or grade checking. Students often get frustrated with these problems which provide the reasons for complaint. On the other hand the same problems occurred during our collaboration with Energoprojekt Company, which resulted in building a life-long e-Learning system through the utilization of Moodle LMS for knowledge verification [Pantovic 2006b; 2006a].

Several questions are raised from this experience: Is Moodle too complicated for novice users? Is there a usability problem with Moodle? Also we cannot disregard the learning effect that can be achieved through On The Go. Standard use of LMS systems simply through the use of desktop computer does not fully involve the user and it cannot provide essential information at any time. One solution to that problem is provided by mobile technologies. By using adaptive technologies we can reformat the content to suit mobile devices. The problem is that by doing so we usually end up with confusing content due to limitations of such devices. This leads us to our research hypotheses:

Hypothesis 1: Moodle LMS has usability issues, which is a major disadvantage of this LMS, and makes positive aspects of e-Learning systems less effective; Hypothesis 2: Usability issues are rising to a higher level on the mobile platform. It is wrong to think of a mobile device as a surrogate for desktop or laptop PC.

3. EXISTING RESEARCH IN THE FIELD

There is a huge bibliography on adaptive and context-aware applications [Corradi 2007]. In particular, lots of papers that have been written on this issue in the context of mobile computing: adaptation to limited device capabilities, network bandwidth, location, QoS and user preferences (among others) have been already deeply studied. However, research area targeting access to Moodle via mobile devices is not adequately addressed to; only a few solutions for mobile access to Moodle content were proposed [Houser 2005; Sharples 2002; Yingling 2006; Bar 2007], and a few researches were conducted concerning the usability of Moodle via mobile devices [Kramer 2006; Soong 2006; Melton 2006; Savolainen 2009]. On the other hand, the usability issues of mobile devices were a common subject among many researches, which shows the effectiveness of experimental method applied in our usability research [Bodn 2007]. Also there were several projects not specifically targeting Moodle, but offering solutions for social interaction via mobile devices [Chatti 2006; Counts 2006; Beale 2005a; 2005b] as well as custom made m-learning solutions [Black 2006; Sharples 2002; Zhang 2006; Costabile 2008].

Multimodal interaction is part of everyday human discourse: We speak, move, gesture, and shift our gaze in an effective flow of communication [Obrenovic 2004]. While multimodal interaction research focuses on adding more natural human communication...
channels into Human-Computer Interaction (HCI), accessibility research is looking for substitutes for ways of communication when some of these channels, due to various restrictions, are of limited bandwidth [Obrenovic 2007]. During our research we addressed general issues of multimodal HCI and universal accessibility by proposing generic frameworks [Obrenovic 2004; 2007]. A specific area of our research is dedicated to usability issues of e-Learning systems and mobile devices [Milovanovic 2009].

Most of the researches rely on adaptive technologies in providing access to e-Learning systems, e.g. mobile browsers. However, this approach has a few drawbacks:

3.1 Limited Screen Size
Standard Moodle pages are designed for access from standard desktop PC, with large screens, but mobile devices have very limited screen size. Mobile browsers wrap content in order to show it in whole, and we lose initial page layout. The convenience of browsing through standard web pages by use of mobile browsers is at a low level. Also images are usually in resolution adequate for standard screens and the small mobile devices do not give the appropriate look.

3.2 Limited Input Methods
Input on standard web pages strongly relies on keyboard usage, but mobile devices usually lack one. Even PocketPC, one of the most advanced mobile devices, has a on-screen keyboard and letter recognition area, and both are significantly slower and more difficult to use than classic keyboard.

3.3 Limited Network Bandwidth
Each web page is actually a bunch of Hyper Text Markup Language (HTML) codes, and each page load and reload actually sends request to the web server and receives the whole HTML code for the requested page. This way, the network overhead can be pretty big, when we open standard web pages via a mobile device. Another point is user experience, because response is much slower when General packet radio service (GPRS) network is in use.

Solution that is more adequate to mobile devices is writing Moodle modules using WML (Wireless Markup Language) instead of HTML, which is targeted to be used with Wireless Application Protocol (WAP) browsers, on limited mobile devices (mobile phones). However, this is still a web request/response application model, and even more adequate for limited devices, but suffers from similar problems as standard web applications. Unfortunately, there are still no realized solutions that can utilize these abilities.

Another approach uses Cascade Style Sheets (CSS) in order to adapt Moodle to a specific device [Lewis-carr 2009]. Main drawback of this approach is that different mobile devices require different Style Sheets. That causes this solution to be unique and not universal for all device types.

4. Rich Client Prototype
In order to test our hypothesis we decided on comparing standard approach to Moodle LMS via desktop computers against mobile solutions. Since usability of LMS systems
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

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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
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 caching 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 offline).

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.

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

ACKNOWLEDGEMENTS

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Computer 37, 9, 62–69.


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):

<table>
<thead>
<tr>
<th>Novice computer user</th>
<th>1 2 3 4 5 6 7</th>
<th>Computer expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>No experience with e-Learning systems</td>
<td>1 2 3 4 5 6 7</td>
<td>Experienced user of e-Learning systems</td>
</tr>
<tr>
<td>I have no knowledge in e-Learning systems</td>
<td>1 2 3 4 5 6 7</td>
<td>I have sufficient knowledge in e-Learning systems</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Pleasant to use</th>
<th>1 2 3 4 5 6 7</th>
<th>Unpleasant to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface is complete</td>
<td>1 2 3 4 5 6 7</td>
<td>Interface is incomplete</td>
</tr>
<tr>
<td>Interface is simple for use</td>
<td>1 2 3 4 5 6 7</td>
<td>Interface is complicated for use</td>
</tr>
<tr>
<td>Interface is fast for use</td>
<td>1 2 3 4 5 6 7</td>
<td>Interface is slow for use</td>
</tr>
<tr>
<td>System is cooperative in completing tasks</td>
<td>1 2 3 4 5 6 7</td>
<td>System is non-cooperative in completing tasks</td>
</tr>
</tbody>
</table>

b) PDA rich client application

<table>
<thead>
<tr>
<th>Pleasant to use</th>
<th>1 2 3 4 5 6 7</th>
<th>Unpleasant to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface is complete</td>
<td>1 2 3 4 5 6 7</td>
<td>Interface is incomplete</td>
</tr>
<tr>
<td>Interface is simple for use</td>
<td>1 2 3 4 5 6 7</td>
<td>Interface is complicated for use</td>
</tr>
<tr>
<td>Interface is fast for use</td>
<td>1 2 3 4 5 6 7</td>
<td>Interface is slow for use</td>
</tr>
<tr>
<td>System is cooperative in completing tasks</td>
<td>1 2 3 4 5 6 7</td>
<td>System is non-cooperative</td>
</tr>
</tbody>
</table>

c) PDA Browser

<table>
<thead>
<tr>
<th>System</th>
<th>Pleasant to use</th>
<th>Unpleasant to use</th>
<th>Interface is complete</th>
<th>Interface is incomplete</th>
<th>Interface is simple for use</th>
<th>Interface is complicated for use</th>
<th>Interface is fast for use</th>
<th>Interface is slow for use</th>
<th>System is cooperative in completing tasks</th>
<th>System is non-cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop platform</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>PDA rich client application</td>
<td>1 2 3 4 5 6 7</td>
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<td>1 2 3 4 5 6 7</td>
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</tr>
<tr>
<td>PDA Browser</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
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<td>1 2 3 4 5 6 7</td>
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<tr>
<td>Mobile phone browser</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
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<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

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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