A Study on the Compatibility of Ubiquitous Learning (u-Learning) Systems at University Level

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Abstract: Graz University of Technology has a long tradition in the design, development and research of university wide Learning Management Systems (LMS). Inspired by the iPhone Style, the available system has now been extended by the addition of a mobile viewer, which grants the student mobile accessibility to all available online content. In this paper, we report on the lessons learned within a study on user experience with this specially designed LMS mobile viewer. The User Experience (UX) was measured by application of a 26 item questionnaire including the six factors Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty, according to Laugwitz et al. (2008). The results showed high rates of acceptance, although the novelty of our approach received a surprisingly low rating amongst the novice end users.

Keywords: Mobile Usability, User experience (UX), u-Learning, Factor analysis

1 Introduction and Motivation for Research

The current emphasis and availability on mobile technologies produces a need to reconsider mobile design principles and mobile usability testing [1], [2], [3]. Jakob Nielsen brought it to the point when he recently expressed that "Mobile Web 2009 = Desktop Web 1998" [4]. New interaction paradigms, e.g. on the iPhone, new mobile system platforms e.g. Android and the increased availability of free wireless network access points, affect the way that end users interact with ubiquitous devices, extending traditional e-Learning into a new phenomenon named: Ubiquitous Learning (u-Learning). Zhan & Jin [5] defined u-Learning as a function of different parameters:

u-Learning = {u-Environment, u-Contents, u-Behavior, u-Interface, u-Service}

This definition illustrates that the application of u-Learning requires different usability aspects as well as different aspects of education [6], [7], [8]. Usability evaluations traditionally investigate whether and to what extent the user interface is suited to the work context of the user and whether it is easy to learn and efficient to handle [9]. In the last years experts increasingly discuss different aspects, including joy of use [10], [11], [12], aesthetics [13], [14], [15], and emotions [16], [17]. Such terms and other related design aspects are generally described as user experience (UX) [18], [19], which is evidently set apart from traditional usability goals such as efficiency, effectiveness and learnability [20].

Within the framework of the development of the university wide Learning Management System (LMS) at Graz University of Technology (with approximately 12.000 students), these rapid changes necessitate continuous improvements, as new possibilities, demands and requirements produce new expectations towards the usability of the offered service and provide new ways of meeting these requirements [21]. In the following, we will first set up some basic theoretic principles and compare their compatibility with our experimental results at the end.

2 Background and Related Work

Designing applications is considerably different for mobile computers (handhelds, Personal Digital Assistants) than for desktop computers. The screen size and system resources are more limited and end-users interact differently. Consequently, detecting handheld-browsers on the server side and delivering pages optimized for a small client form factor is inevitable [22]. Activity within the vicinity of the user can negatively affect the users concentration, consequently, the presentation of information in short, simple pieces (chunks of information [6]) is an important rule in design of u-Learning applications [23]. A regularly used LMS can provide content relevant information and connect the learners to their learning community at any chosen time and location. To date, the approach of a LMS interface for mobile devices is relatively pervasive; however this must be supported by specially designed courses and materials. The most important and generally accepted guidelines include: Keep things as simple as possible. Every mobile device still has limited resources. It is recommended to use a simple, mainly text-based interface with few small images. Pages must always be designed to allow dynamic resizing, fixed-size designs (e.g., using tables and transparent images for sizing table columns), and pages that need horizontal scrolling must be avoided (refer also to [24], [25], [22], [26]).

2.1 Categories of Mobile Usability

The usability of mobile interfaces can be tested on different categories as shown in Fig.1, according to [27]. The device category includes hardware and system implementations, the browser category refers to the supported web technologies and finally the website category is concerned with structure, content and layout. The categories are influencing each other and produce together with the context of use an integrated experience for the user.

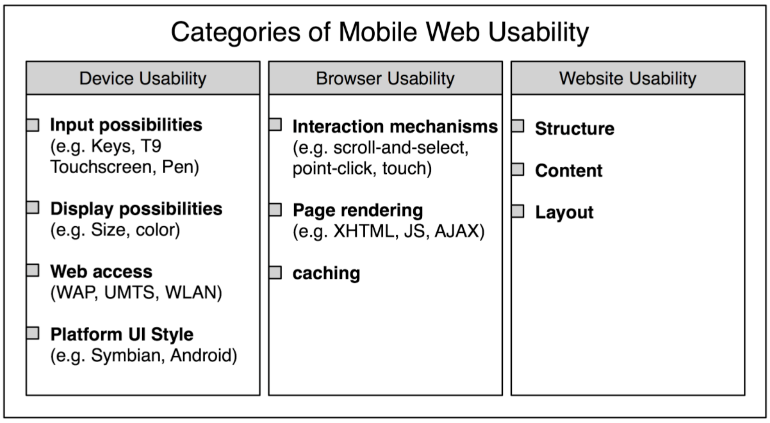

Fig. 1. The categories of Mobile Web Usability [27]

In the mobile LMS website scenario, the user experiences only the top category, which is influenced by the underlying categories. Usually the lower categories are sparingly taken into account when designing a mobile web interface. A pure integrated approach will render complex tests and results while just one layer might not be sufficient to explain usability issues.

2.1.1 Device Usability Category

The Device Usability category deals with the actual hardware and operating system of the mobile device. It is completely dependent on the manufacturer's design. If a phone is designed to support mobile browsing as a primary focus, this layer will influence the overall mobile web browsing UX in a positive way.

However, even if the manufacturer decides that browsing is not the key application, it is still possible to support the user interaction, e.g. by supporting the input and interaction mechanisms for focus control on these compact devices (mostly scroll-and-select) with a list style narrow layout and reduced content. If the web application uses device profiles to identify classes of mobile phones, the use of hard keys may be considered for some devices.

2.1.2 Browser Usability Category

Most of the current mobile devices provide some kind of browser, developed by Access, Google, Microsoft, Nokia, Teleca, Openwave, Opera or others. These browsers are most likely to support xhtml or xhtml mp, which are restricted versions of standard html/xhtml, as the primary markup language. CSS is mostly supported, while some newer browsers also support scripting and even AJAX. Using technologies such as caching and prefetching will optimize the reaction rate of a mobile website and hence improve UX.

2.1.2 Website Usability Layer

The Website Usability layer deals with all structure, content and layout issues. While the other layers are widely subject to manufacturer restrictions, this layer provides the most possibilities to influence the final web application.

2.2 Mobile Internet Design Principles

The following principles are presented in the form of metaphors, which consist of generalizations on user behaviour, context and interaction. They emphasize important guidelines for mobile web design. A comprehensive collection of best practices on this topic can be found at the W3C mobile website[1].

2.2.1 The Fat-Man-Walking-No-Narrow-Path principle

Imagine a fat man trying to cross a very narrow plank bridge over a deep canyon; unless he thins down he will not be able to cross the river. The same applies to layout, content and code. Unless the user has a touch phone or PDA with a QVGA screen or higher resolution, all websites will be restricted to a narrow resolution. The metaphor can also be used for the file size. The Speed of a site depends considerably upon the kind of connection but the smaller the content the faster the site.

The fat man is also applicable for the device hardware. The users don't want to carry large, heavy devices in their pockets and so the manufacturers build small devices, with the weight as an attractive feature and comparable advantage. However, small, lightweight devices imply a small screen.

1. Use a narrow layout.
2. Flexible/Adjustable/Optimize original layout.
3. Use lean code.
4. Avoid large graphics.
5. Label files with type and size.

2.2.2 The Free-Bird-On-The-Fly principle

In the same way that a bird, having flown out of it's cage and experienced freedom, independence, choice, speed and the advantages of being able to change direction rapidly, will refuse to return to the restrictions of it's cage, the user will most likely avoid energy consuming interactions in order to remain free (as the mobile device runs on batteries the user is only has a limited time before the device needs to be recharged.) Being always on the fly means constant changing, correspondingly instable net quality and even connection breakdowns. At this point, it is important to think about what the website does when the user is involuntarily disconnected from the net. How much effort is necessary to login again? For example, the opera browser on the Nokia 95 (N95) closes immediately on being disconnected from an (unstable) WLAN.

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[1] See W3C Recommendation (29 July 2008) Mobile Web Best Practices 1.0 http://www.w3.org/TR/mobile-bp/

1. Use caching if possible.
2. Don't rely on cookies or scripts.
3. Avoid periodic reloads.
4. Avoid automatic redirects.
5. Avoid unnecessary animations.

2.2.3 The one-handed-bandit-on-the-run principle

Imagine a student on the campus interacting with his mobile device while walking from one classroom to another. He moves quickly, avoiding other students and thereby uses the instant messenger on the phone to make an appointment for lunch. Usually mobile phones are designed to be used with just one hand (if you need two hands then it's a netbook). Even with a PDA or Touch phone, most interaction is made one-handed, the other being used to hold the device. When the user is also in motion, as in our example, the cognitive resources allocated are limited since his attention must necessarily be divided. Operating with one hand also means that the input capabilities are limited and slow in comparison to desktop web users. The mobile web users are likely to have more immediate and goal-directed intentions, such as finding specific pieces of information, which are relevant to the current context. W3C states that, due to the unsuitable ergonomics of the device, mobile users are less interested in lengthy documents or web browsing.

1. Reduce text and character entry to a minimum.
2. Support input mechanisms of the device with the layout.
3. Use a flat site structure, support navigation.
4. Reduce the content to the max.
5. Support goal directed actions.

2.3 Mobile Internet Testing

As mentioned in the introduction, for reliable mobile interface testing it is important to consider the context of use. While field testing is useful in certain situations, we considered the lab setting to be the most efficient for our type of study.

Kaiikonen et al. [28] compared a field and a lab test for mobile devices. Against their initial expectation they found that there were exactly the same number of issues found in each test and concluded that the more efficient method of lab testing was most beneficial and more time and cost efficient. Also Kjeldskov & Graham [29] discovered, in several tests, that the benefits associated with field studies were not realized. Ryan & Gonsalves [30] discussed the effect of context on mobile usability. They demonstrated, by utilizing client side processing and location context, that a mobile application was able to achieve objective performance and subjective usability measures comparable to those of PC based versions. However, the mobile web based application performed badly because it was unable to take advantage of location context or client-side application code. As a way for simulating real world situations and thereby imitating the mobility aspects of tasks, Lee & Grice [31] suggest the use of scenarios. Burns [32] reported that constructing a scenario that was simple to convey to users enabled them to rapidly comprehend the potential uses of the tested application. The scenario was stated to be useful as it avoided confusion as well as any need to over-explain the application. Burns also found that scenarios enabled users to begin interacting immediately with the application. The scenario also served to stimulate the users' imagination, inspiring them to make several other suggestions for the applications potential use. In combination with user interviews and thinking aloud, the use of scenario-based approaches in lab settings has shown to be reliable and efficient.

For further exploration of user satisfaction and UX, questionnaires have proven to be a valuable tool, also for the mobile paradigm. Laugwitz et al. [19] developed the User Experience Questionnaire (UEQ), which provides a fast measurement of different quality metrics related to UX. The items are organized as semantic differentials and contain a set of potentially relevant concepts and statements, which include Usability criteria as well as UX criteria. The results are grouped into 6 factors: Attractiveness; Perspicuity; Dependability; Efficiency; Stimulation and Novelty.

3 Methods and Materials

The central requirement of our mobile LMS interface implementation was that it would support a diverse set of mobile devices. Whilst technologically different device classes are taken into consideration for the optimized display of the information, the overall style of the interface must remain the same for every device. For the redesign of the mobile web content, a style similar to the iPhone was chosen due to the clear and easy navigation of this device.

3.1 Experimental Design

Our LMS interface for mobile devices (http://tugtc.tugraz.at/wbtmaster/pda) was first tested in a laboratory setting, following the general rules of usability engineering [33]. A central goal was to test User Experience (UX) according to Laugwitz [19]. The tasks and interview questions were targeted at the layout and navigation of the website. Seventeen (N=17) people took part in the experiment on a voluntarily basis; all of them were either currently students or had previously finished their studies. 11 out of 17 had no previous experience with the LMS, therefore providing results unbiased by either expectations or previous knowledge. It was also possible to compare their results with those of the second group (N=6) who were familiar with the standard web interface and had knowledge of the structure and the possibilities. Two kinds of mobile devices were used for the experiment: the Apple iPod Touch (iPhone), used by 15 students, and the Nokia N95, used by only 2 students.

3.2 Procedure

The approach combined the Thinking Aloud Method with a User Interview. Each test person was given six tasks: to find specific information on the website. The tasks were selected in order to show the users the most important functions and interfaces.

This was done to ensure that the test persons were able to see, and learn about, as much of the interface as possible. The users were instructed to verbalize their actions. During the tasks, the facilitator asked additional questions, targeting at comprehension and layout. All occurring usability issues were written down. In the end the UEQ was used to assess the User Experience.

3.3 Results

The study revealed usability issues on different layers, violating the principles discussed previously. The *fat-man,* for example, occurred as the interface forced the user to use excessive zooming and scrolling on all parts of the site (see fig. 2), and a fixed page width was used that resulted in very small text. Also in some parts of the system the gap between links was too small to be used with a touch screen, which can be seen as a further application of this principle. A frustrating constriction for the *free-bird* was the automated "first-letter-big" function of the iPhone when logging into the system, as the login was case-sensitive and it was not permitted to store the login code. The *one-hand-bandit* appeared in the form of confusing lists and forum post, with difficult to understand structures.

Fig. 2. Usability issues found necessitated restyling of the mobile LMS interface to support different interaction mechanisms

After the testing, the students completed a questionnaire designed according to the methods described by Laugwitz et al. It consisted of 26 questions, each relating to one of the six categories: Attractiveness; Perspicuity Dependability Efficiency Stimulation Novelty, in the format of a seven stage semantic differential.

	1	2	3	4	5	6	7		
creative	○	○	○	○	○	○	○	dull	3
boring	○	○	○	○	○	○	○	exiting	6

The completed questionnaires were evaluated by an intersection of each category and thus resulted in an overall rating of these quality metrics, revealing positive values for all aspects of the tested interface. The results of the UEQ in figure 3 below show that the users rated the perspicuity very high, while the novelty of the approach received a low rating. This is surprising as most of the users were novices to this system. The evenly high rates of attractiveness, dependability and efficiency show an overall acceptance, positive UX and good Usability.

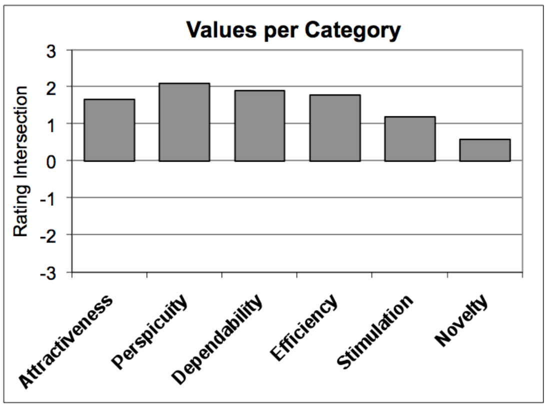

Fig. 3. Results of the User Experience Questionnaire

4 Conclusion

During the redesign, the colour theme was intentionally kept in grey with sparingly used color, to keep the attention on the content. This may account for the low novelty rating, as the color grey is perceived as being neutral. The site structure was reduced to the most necessary and convenient items in mobile contexts. Many links and functions, which required text entry, were removed to support scroll-and-click interactions. This complies with the *one-hand-bandit-on-the-run* principle, as the mechanisms of the device are supported, the reduction of content and text entry fosters a clear structure and thus supports goal oriented actions of information retrieval. This may be the reason for the high perspicuity values. All graphic items were removed to preserve bandwidth. This complies well with the *fat-man-walking-no-narrow-path* principle. The violation of the principle by excessive zoom and scrolling was a usability issue with the users. The next iteration of the interface took into account this principle and used a narrow layout. The Internet connection during the test was high-speed wlan for the iPod Touch and N95. However, the connection category of the N95 was very low and had spontaneous breakdowns. This resulted in the abrupt closing of the browser and continually frustrated the users. Although in a controlled laboratory setting, the principle of the *free-bird-on-the-fly* was violated, this time on the browser usability category. There were some more usability issues; however these examples show how the three principles impact mobile interface design. The suggested implications of these interaction metaphors are exemplary and there are surely more items to be added. It can be concluded that the implementation of intelligent pervasive learning environments demands holistic approaches of thinking, design and testing.

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