IMPLEMENTATION OF MOBILE LEARNING USING
SMART PHONES AT AN OPEN UNIVERSITY: FROM
STYLESHETS TO PROXIES

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ABSTRACT
This investigation includes a description of the mobile friendly implementation of both text and multimedia content using a smartphone (a Treo 650) from a content provider’s perspective. This study involves research into the application of a user interface for multimedia content as well as an examination of the limitations imposed by the small size of mobile devices. Implementation has involved the use of CSS stylesheets for the content and the use of proxy applications to convert content “on-the-fly”. A table displaying the comparative features of different mobile conversion proxy applications is provided.

KEYWORDS
mobile learning, stylesheets, proxies, mobile conversion

1. INTRODUCTION
This investigation includes a description of the mobile friendly implementation of both text and multimedia content using a smartphone (a Treo 650) from a content provider’s perspective. This study involves research into the application of a user interface for multimedia content as well as an examination of the limitations imposed by the small size of mobile devices. Implementation has involved the use of CSS stylesheets for the content and the use of proxy applications to convert content “on-the-fly.”

2. SCOPE
This research investigation has been conducted using a PalmOne Treo 650 (Treo) smartphone. Compared to a PDA and an ordinary cell phone, the smartphone is characterized as a device with on-demand connectivity to the World Wide Web (WWW) via a network provider, and with an operating system designed for installing additional software. In the case of this investigation, the operating system is Palm OS with 10Mb RAM. There is 28 Mb of built-in, non-volatile storage, plus a SD memory slot for data and applications. The screen size for this device is 320 * 320 pixels. In addition to the five-way directional button and the touch screen interface, this device is also equipped with a miniature QWERTY keyboard. The Treo comes with a proprietary web browser Blazer v4.0 and an email client VersaMail. For this investigation, we have limited our tests on the software originally shipped and supported by the vendor.

The Treo has Bluetooth and wireless web (WiFi) connectivity. Bluetooth is an open telecommunications specification using short-range radio links in the 2.45 GHZ band for seamless wireless very short-range communications of data and voice between both mobile and stationary devices. WiFi is a limited-range
wireless networking protocol based on the 802.11 family of standards; it uses spectrum in the 2.4 GHz range to exchange data at broadband speeds.

This investigation is concerned with two related areas: viewing WWW and multimedia content using a mobile device; and entering and inputting content using a smartphone. These areas of study involve research into the application of the user interface, the multimedia capabilities, and the limitation imposed by the small size of mobile devices.

Firstly in viewing content using a smartphone, the investigation will be conducted from a content provider's perspective, initially testing the technical capabilities and the challenges involved in viewing web pages on a small mobile device. The same framework will be employed in examining the use of multimedia clips. As part of this study, possibilities for adding interactivity between the students and the online materials will be tested.

Secondly, contributing content via a smartphone, the possibilities and challenges involved in entering content using a mobile device will be examined from a user's perspective. This will include inputting text and multimedia clips using the smartphone. Lastly, some of the unique functions of mobile devices will be examined, focusing on the possibilities and the challenges that they open up for learners.

3. PROVIDING WEB CONTENT

Accessing the WWW using mobile devices is becoming a common phenomenon. For example, according to BBC statistics, there were almost 250 million requests for their content from listeners or viewers using mobile phone in 2005 (Yanda, 2005). Viewing webpages using small mobile devices can be challenging. Common problems include the need for two-way (horizontal/vertical) scrolling, excessive vertical scrolling, or simply unusable pages. With the growing number of users viewing webpages on their mobile devices, content providers should be concerned about the usability, or "mobile friendliness", of their web pages. In some cases, the problems are due to poorly designed web pages. In other cases, it is related to the browsers capability of rendering pages in a readable format.

The Teco mobile browser, Blazer, that we tested in this research supports XHTML, CSS 1, and some Javascript. XHTML has been called "the next generation" of HTML because it is considered to be a hybrid or intermediary solution between HTML and XML. XML describes data; HTML displays data. XHTML is much stricter than HTML. XHTML can be interpreted by both XML and HTML browsers. CSS (Cascading Style Sheet) is a standard for specifying the appearance of text and other elements. CSS allows developers to implement style elements to structured documents, for example fonts, spacing, and other layout features. Javascript is not to be confused with the Java programming language. It is a scripting language, often referred to as a simplified version of Java. It need not be compiled, and the source code resides within the HTML document.

To test the conformity of the browser with CSS 1, the W3 CSS 1 Test Suite was accessed as well as the W3 CSS Mobile Profile Test Suite (W3 CSS 1 Test Suite n.d, W3 Mobile Profile, n.d.). We found significant incompatibilities from the first test run through. Most significant was the lack of support for embedded [object] elements. Once we modified and removed the use of [object], the device passed all the significant tests for CSS 1.
3.1. Mobile friendliness

There are different approaches possible in rendering a web page mobile friendly. One approach is to create a layout that works for both the desktop and mobile browsers. In the past, this was not a viable approach because of the different markup standards on mobile phones. The older standard is the Wireless Application Protocol (WAP 1.2). It used a different protocol and markup language, which tried to accommodate both content and interactivity on mobile devices. Currently, most mobile phones support the WAP 2.0 standard. The revised standard is a stripped-down version of the XHTML 1.0 and CSS standard. As most web page content is marked up with XHTML with CSS formatting, adapting these pages for mobile devices is much easier.

The open source Learning Management System Moodle, for example, displays well on both desktop and mobile devices with the same presentation “look” and same content. When browsing with a desktop browser, a Moodle page is presented in a three-column layout. However, when browsing with a mobile device, the same page is displayed as a linear one-column page. On the other hand, there are some popular online resources that are not mobile friendly at all. One example is Wikipedia. The default template uses tables to do the layout of the site. Most web developers are familiar with the problems in using table tags for layout. The unusable rendering of Wikipedia pages on mobile devices reconfirms the need for fluid design as reported in a previous article (McGreal, Tin, Cheung, et al. 2005).

Figure 2. With the default template design, Wikipedia is unusable on a mobile device.
Crafting a content rich page that works for nearly all platforms suggests the need for a thorough understanding of the limitations of different platforms. There are also guidelines to help content developers make their web pages compatible with nearly all platforms. The main benefit for this approach is that once the users have become familiar with, and developed a mental image of the web page, they can easily navigate the same page using a different platform. The cost of using this approach is that the content has to be compatible with the lowest common standard across different platforms. Usability is also a challenge when using this approach. It is difficult, if not impossible, to make a web page display optimal for both big and small screens. For example, a well-positioned navigational menu designed for a desktop PC is usually too long and too detailed for mobile usage. After testing the web browsing capabilities of the mobile devices, and reviewing the Mobile Web Best Practices 1.0 Document from the W3C Mobile Web Initiative, the desired qualities for constructing a mobile friendly webpage can be discerned.

Richards (2002) proposes the use of learning objects that are designed for interoperability and reusability. This design feature of learning objects ensures that the content can be viewed on a mobile devices as well as desktop PCs. High quality metadata facilitates the discovery of appropriate content whether the users are displaying content on a desktop or on a mobile device. The benefit of using metadata is amplified on mobile devices because of the difficulties in typing search terms using the small keyboards. Repositories with metadata browsing functions provide mobile device users with an easy way to rediscover related content.

3.2. Adaptation

With this approach, different markup and layout designs are developed and delivered according to the type of device. In other words, the content and presentation are separated. This can either be accomplished on the client side using a media-dependent import for CSS stylesheets, or on the server side with a device detection function and multiple templates.

One finding from our research is that when using the [@media] rule to link to media specific CSS stylesheets, many devices deploy the stylesheets for both "screen" and "handheld" media types as well as non-media specific stylesheets. If there is any non-mobile friendly formatting in the stylesheet for "screen," this formatting is inherited for use on mobile devices unless a mobile-friendly style is applied in the stylesheet for "handheld."
3.3. Proxy Conversion

A proxy is a server that sits between the end-user and the source of content. By implementing this infrastructure, and directing the students to use it, content can be converted into a mobile friendly version on the fly. The proxy automates the process of adapting a page for mobile devices. The greatest advantage of this approach is that it facilitates the conversion of both internal and external content. The intelligence and processes for conversion are also centralized with this approach.
For some mobile devices, accessing the web is conducted through a proxy by default. These proxy servers are maintained by the network carrier or browser provider. One example is the Opera Mini browser for phones. A proxy can also provide an added layer for personalization functions (Chen, 2005). Personalization allows retrieving and customizing a page based on a user’s profile. A proxy, backed by a device profile database, can also add an intelligent layer to customize content specifically to a device’s capability (Ally, 2005).

There are some free mobile conversion proxy servers available for use by the public, for example, IYHY.com; Skweezr; and Google Mobile. This research investigation determined that Google Mobile is the most capable in adapting content for mobile presentations. The researchers also came to realize that the content providers did not welcome requests from these proxy services. In particular, content providers were concerned that Skweezr was replacing the advertisements on their pages. Wikipedia.org is currently blocking access from IYHY.com.

Table 1. Summary of mobile adoption functions of different free proxy services.

<table>
<thead>
<tr>
<th>Basic and mobile specific conversion offered by proxy</th>
<th>Processed by browser (without proxy)</th>
<th>Processed by IYHY.com</th>
<th>Processed by Skweezr</th>
<th>Processed by Google Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalized account</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Remove images</td>
<td>Optional</td>
<td>Default</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>Resize images</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Form submission using HTTP (e.g. login)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Linear listing of tabular content</td>
<td>Optional</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Resize fonts</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Alert for non-compatible file format</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Paginating a long page into multiple pages</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Group and minimize navigational menu</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.4. Multimedia content

The Treo supports a number of multimedia formats including 3GPP2 video, which is a new video format designed specifically for 3g telephones, as well as MP3 audio. These capabilities allow developers to use media beyond text and still images.

Unlike simple HTML documents, it is technologically difficult and inefficient to adapt multimedia files for mobile devices on-the-fly. A reasonable approach in rendering multimedia applications on mobile devices is to make the files available in multiple sizes and resolutions. MPEG 1 Layer 3 is the most commonly accepted format for audio. For video, we find MPEG 4 is more compatible on both the desktop and mobile media players. Video encoded with a 3GPP container format can also ensure compatibility for mobile usage (3GPP).

Our research shows that web content can be highly mobile friendly. A good design template can ensure the usability of content on different devices. For external content, a proxy can greatly improve the mobile user’s experience. The new WAP 2.0 standard and improvements in the capabilities of the mobile browsers also contribute to making smartphones a viable platform for multimedia content, as does the ongoing improvement of mobile device computing power and the speed of the wireless data infrastructure.
3.5. Current challenges

One on-going challenge for web design in general is how to minimize the number of clicks. In desktop web browsing, there is a three-click rule as the standard for good navigation. For the mobile web, starting from the referral of a search engine, the entering of a URL, or from a bookmark, scrolling to the navigation menu may already consume multiple “clicks.” The mobile environment has a much higher demand for good navigational design and site structure. Personalization and intelligent agent can help to deliver the right content with less user input. And for mobile website developers, the mobile users’ need for “media snacking” may mean a generalized site with lots of content may not necessarily be better than a small site with one specific focus.

At the same time, when the user is at the page they want, mobile devices do not handle interaction between the student and the online materials very well. Developers for the desktop environment can use Javascript to support client-side interactivity. Asynchronous JavaScript and XML (AJAX), a recent development tool enables desktop web developers to create rich internet applications. This research investigation did not find that Javascript could be depended on when used on mobile devices. Some simple Javascript functions worked on mobile devices with a limited level of interactivity. In particular, the mobile browsers could not handle complex Javascript applications, for example, the Hot Potatoes™ interactive quiz package and SCORM objects run time environment (Cheung et al., 2006).

Adobe Flash® and SVG are two scriptable environments for interactive content. Adobe has developed Flash Lite 2.0 for some mobile devices. Unfortunately, neither Flash Lite nor SVG were available for the device we tested.
4. CONTRIBUTING AND ENTERING FROM A MOBILE DEVICE: END USERS’ PERSPECTIVE

Entering text using a phone keypad is always a challenge. By balancing the form factor and the ease of text input, many mobile devices now include a mini size QWERTY keyboard, also known as a thumbboard. Our research found that once the user is familiar with the mini keyboard, text input rate can be as fast as 24 words per minute.

The device tested is equipped with a microphone and video camera allowing users to capture audio, still pictures and video. Saving clips and annotating them is already quite popular using PCs. Uploading and sharing clips on the spot when and where needed is a particular advantage of mobile devices that can support real-time remote collaboration.

Many mobile device browsers do not support uploading files via a web form. This is a significant hindrance for users who are used to blogging or for students wanting to upload assignments on the road. Currently, there are some proprietary add-on programs and services that allow uploading photos to a weblog, so it could be expected that shortly smartphone developers will come up with generic file upload functions for mobile devices.

5. FUTURE POTENTIAL FOR LEARNING AND TEACHING

Although user input, when compared to a desktop environment, is usually more difficult to do on a handheld device, the mobile platform offers some other capabilities a desktop can not offer. Some mobile devices have built-in or add-on Global Positioning System (GPS) capability. This is especially valuable for open distance learning institutions like ours because of the distributed nature of students. With GPS data readily available on mobile devices, students can reference their contribution with precise location information when completing assignments in subjects like Geography, Biology, Geology, Ecology etc.

Matrix or two dimensional bar coding is a machine readable data format. Similar to widely used barcodes, but with more data capacity, the decoder translates the visual code into data. In Japan, QR code developed by Denso-Wave Corporate is a proven successful implementation of 2D barcode. Mobile phones equipped with a camera and the decoding software can translate the QR code into a URL, and retrieve additional information online. At the technical level, matrix code eliminates the step of entering a URL by hand and makes information retrieval as easy as pushing a button. At a higher level, the added convenience has opened up different possibilities, enabling interactions between the learner and the environment.

Figure 5. Examples of matrix type bar codes.
6. CONCLUSION

Technically, mobile devices have become more advanced enabling a rich experience in mobile learning. The mobile environment has become a mature information medium. Retrieving information while on the road is just one immediate benefit that can be offered to mobile learners. With the multimedia capturing functions, the new generation of smart phones allows students to bring interactive content into their collaborations. With other location awareness functions like GPS and matrix code, mobile devices can support an even higher level of interactivity between students and their environment. In the Internet era, educators have been introducing a wide variety of online activities into teaching. In the emerging mobile era, educators should continue exploring the now possible real life, mobile-device-enabled activities for supporting learning.

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