Responsive Online Book based on the Multimedia Learning Theory

Ana Emília Oliveira
Universidade Aberta do SUS
UnA-SUS/UFMA
Rua Viana Vaz, N 41, Centro
São Luís - MA, Brasil
anaemilia.unasus@gmail.com

Rômulo França
Universidade Aberta do SUS
UnA-SUS/UFMA
Rua Viana Vaz, N 41, Centro
São Luís - MA, Brasil
romulomf@gmail.com

Elza Ferreira Universidade
Aberta do SUS
UnA-SUS/UFMA
Rua Viana Vaz, N 41, Centro
São Luís - MA, Brasil
bernardes.elza@gmail.com

Francisco Gregorio Silva
Universidade Aberta do SUS
UnA-SUS/UFMA
Rua Viana Vaz, N 41, Centro
São Luís - MA, Brasil
greg.unasus@ufma.com

João Gabriel Castro
Universidade Aberta do SUS
UnA-SUS/UFMA
Rua Viana Vaz, N 41, Centro
Sao Luis - MA, Brasil
gabri.gcl@gmail.com

ABSTRACT

The growing popularity of mobile devices with internet access has created a unique opportunity for exploitation by Distance Learning. To develop educational content for mobile devices is necessary to pay close attention to the technical aspects involved in educational interfaces. In this paper a mobile educational object developed by UNASUS/UFMA is presented: the responsive online book. The conception of its interface is based on the Multimedia Learning Theory and development standards for Responsive Web Design.

Keywords

Online Book, Responsive Web Design, Educational Interfaces

1. INTRODUCTION

The Internet increasingly comes within reach of a larger number of people, besides being accessible by a wider range of devices, such as mobile phones and tablets. This fact has motivated the exploration of educational contents on mobile devices, in order to increase the reach of the target audience. Both teacher and designer, at drawing level or at the conception of an object with educational interface, are architects of learning environments and should be aware that a good design of an interface ensures students' attention focused on content, otherwise stimulates disorientation, which leads students to concern themselves with the particularities of the interface, and only after, to the learning contents, according to Lima and Capitão.[7]

Therefore when developing a multiplatform educational object, adapted to mobile devices, it is necessary to think about maintaining the same pedagogical principles which governed the conception of the interface when its view is switched between different screen resolutions. The interface design should be consistent with the goal of the educational object as it was planned by the various actors in the teaching learning process, no matter which access device used.

The objective of this paper is to present an adaptable multimedia educational book to mobile devices through the "responsive web design" technology, as a learning object designed for distance learning (DL) courses offered by UFMA (Federal University of Maranhão) through UNASUS (The Open University of Brazilian National Health System). This work contributes as an important step towards greater accessibility of distance education through mobile devices exploration.

2. ONLINE BOOK AS AN EDUCATIONAL OBJECT IN DISTANCE EDUCATION (DE)

Technological evolution enabled the exploitation of digital books, and some courses in distance mode use this type of resource on a large scale. According to Vasileiou and Rowley [10] "A digital book is a digital object with text and other elements, which arises as a result of the integration of the familiar concept of a book with features that are part of the electronic environment. E-books typically have features such as search functions, cross reference, hyperlinks, (...), multimedia objects and interactive tools."

Within the experience in Distance Learning in UNASUS, digital books, here called online books, are adopted as the main source of presentation of contents in their courses. These books are made available in web accessible format.

The online book is one among many others pooled resources in Virtual Learning Environment (VLE), which is an application used to manage institutions' online courses. The book presented in this work was implemented in educational management platform (LMS - Learning Management System) of

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open source "Moodle".

Moodle was developed by Dougiamas [4], being designed in order to serve as an environment for collaborative learning. It is characterized as a free constructivist environment, conducive to the development of a student-centered learning context. Antonenko et al. [1] emphasize that Moodle provides to students a real learning context, through the involvement with authentic and contextualized tasks. This is made possible by the integration of various tools such as glossary, wiki, blog, posts and hypermedia resources. Due to these aspects, Moodle presents potential to collaborative practices and distance practices. In Brazil, Moodle, after approved by MEC, has been used as the official platform for distance learning in various educational institutions. [**?**] The conception of an online book interface, this being a learning object, must be aligned to appropriate pedagogical principles, meeting requirements from content presentation and interaction form to the amount of information presented, as an attractive interface, with suitable interaction devices, has a positive effect on its usability, acceptance, as well as its potential for promoting learning.[16] Interfaces in this background are called Educational Interfaces.

In this context, several studies in educational interfaces have been conducted over the years, supported by theoretical principles of pedagogy, to promote the satisfaction and motivation of students in the teaching learning process. The following are some technical aspects involved in substantiating the interface of educational applications, according to Reategui et al. [17], which should not be neglected during the construction of a mobile educational interface. .

2.1 Use of Images

According to the principle of multiple representation, it is better to present an explanation through text and graphics than just through texts [14]. The authors claim that the images may be used for different functions: decorative, representative, organizational and explanatory. Therefore the use of images to illustrate concepts is essential in educational contents. To identify whether an educational interface meets such principles for using images, the following questions can be answered: a) the number of images disrupts cognitive load? b) are there pictures to illustrate concepts? c) unnecessary decorative images are used? d) are there texts and images together?

2.2 Texts Presentation

To the learning process through reading be performed in a fluid manner, it is important that text and information is presented in interfaces in an appropriate manner. Based on guidelines set by Bailey et al. [5], some questions can be raised in this regard: a) Text fonts have an adequate size? b) Is there the possibility that the text font can be increased/decreased according to the need of each user? c) Is there visual consistency in the presentation of information (titles, formatting, layout of text and graphics)?

2.3 Orientation and Navigation

The resources of an interface that let the user know what activity is being developed, what has already been done and what other activities are available, are called mechanisms of orientation and navigation. [9] confirms, in his study, that the good orientation system should provide answer to the following questions: a) at any time it is possible to know where the user is (through labels and titles)? b) links are easily recognized (underlined or bolded links, buttons easily identified)? c) icons that give access to other pages and functions are easily understandable?

2.4 Interactivity

The interaction in an educational interface opens numerous possibilities for students. However, to enjoy the benefits of these resources, it is essential to design and deliver appropriate interaction mechanisms [19]. In the case of educational interfaces, the aim it to identify whether or not they explore these interactive resourced. Some issues may be related to: a) the interactive features used in the interface goes beyond links and buttons to advance or rewind the presentation content? b) is there possibility to change the environment settings in order to get different answers, according to their actions?

2.5 Layout

Users do not realize the reading of web pages, but track in an attempt to locate words or phrases that capture their attention [8]. The size, color and layout of elements on the page influence its search facility. Bigger elements are found more quickly as well as elements in saturated colors that contrast with the background of the screen. Experiments show that most users see the density of a page in the same way, and the excess of elements reduces the performance on information search [20]. As for the other aspects, some issues have been established: a) there is a consistent alignment (order) of the interface items (text blocks, columns, checkboxes, radio buttons etc)? b) the interface has reasonable voids, preventing cognitive overload? c) the interface developed provides a standard template for all screens, following the same colors, buttons, structure and font size?

3. MOBILE LEARNING AND RESPONSIVE WEB DESIGN

Several studies point to the increasing number of mobile device users, which is now much larger than the number of traditional computers users [13]. The fact that the use of mobile devices with web access is growing at a fast pace has motivated the migration of various types of web content for such devices, in order to reach, with more coverage, the target audience.

This fact made a new concept in the world of distance learning arise: the m-Learning (mobile learning). [15] defines m-Learning as "the exploration of mobile technologies with wireless networks, to facilitate, support, enhance and extend the reach of the teaching-learning process." [6] shows that because a mobile device is "always on", this provides an online education on a much broader level, as it adds to the already proven benefits of e-learning the convenience of learning anywhere, anytime, not limited to a physical line connection and with a device that is often cheaper than a desktop computer or notebook.

Due to the increasing number of smartphone users, to develop services geared to mobile devices has become an im-

portant business strategy in the web [11]. Therefore, to seek ways to adapt the web contents to mobile devices is a key issue for the success of most applications. Traditionally, to have a mobile version of a website was necessary to create multiple customized versions to the characteristics of each target device [11]. [2] cites that "building content with the same objective, but specifically for each device, would unnecessarily raise the cost of creating and maintaining the same."

Therefore, the most appropriate solution for the proposal of an educational object with a mobile web interface should provide that the same page is conceived, from its conception, to be displayed properly by all the possible means of access. A solution that fulfills this requirement is Responsive Web Design.

3.1 Responsive Web Design

Responsive Web Design is a methodology for developing web interfaces that uses customary languages to build the pages (html, css and javascript) in such a manner that they become "responsive", other words, dynamically respond to changes related to the size of the browser screen and the type of access device, adapting its interfaces for an adequate viewing in each device. This concept originated from the publication of an article by [12], where it is shown a set of techniques that ensure responsiveness to a web design. This methodology is based on three principles related to the use of web development technologies:

3.1.1 Fluid layout

Develop pages with fluid layouts (or flexible grids) is the first step toward responsive design. It means making a dynamic adaptation of the size of the pages' blocks so that no content is hidden behind horizontal scrollbars. This principle ensures that all content is displayed, regardless of the screen resolution of the access device. To achieve this, the method is not specifying absolute measures in the project's layout, but relative measures, with units as percentages and "em". When using relative measures, automatically the layout becomes fluid, being dynamically scaled for each screen resolution.

3.1.2 Images and flexible resources

It is necessary that images and other resources of the responsive web page also become adapted and be flexible. Through various techniques, it is possible to make this happen. The basic rule is also not to use fixed measures, but relative to the container that holds the image or resource.

3.1.3 Use of media queries

Through Media Queries, it is possible to hide, unhide, reposition and modify elements and interactions, according to the current resolution that is being used when accessing the web pages. Media Queries is a W3C recommendation that uses the so-called Media Types, being possible to specify advanced parameters so to adapt parts of the codes specifically for different combinations of devices and their features like screen size, pixel density, and others.

4. RESPONSIVE ONLINE BOOK INTERFACE

By embracing responsive design into an educational object, it is necessary to think about the processes of adapting the elements of its interface for various devices in a way that the pedagogical principles of educational interfaces are maintained in the transition between different screen resolutions. A responsive design in particular should not cause inconsistency in the fulfillment of the purpose of the educational resource, the way it was planned by the various actors in the teaching learning process.

[18] define learning objects as any additional resource to the learning process that can be reused and fulfills the requirements of accessibility, interoperability and durability. Ideally, a learning object must seek to fulfill these requirements. The methodology used for the design of responsive online book presented in this paper sought to apply these requirements to project and extend questions about educational interfaces exposed in section 2 the scope of an educational mobile interface, thinking of the dynamic adaptation of the interface elements process.

Keeping in mind all these aspects, the book online was implemented as a framework for building books. The framework consists of a set of html, css, javascript, image files and others, within a directory structure on a web project. Each book developed uses this design as a basis, leveraging a set of pre-built elements (accordions, tabs, image zoom, modal window, animations, interactive widgets, mini-apps, embed media, etc.) for use in its content. At the same time, ensures that the book being developed follows the development rules established in the framework. Such rules encapsulated in the framework determines the template of the book and the behavior of all the elements of responsive interface. The framework thus provides rapid development of books through the reuse, and interoperability and accessibility via responsive design, being durable as a digital resource constantly updated.

The following will show how the elements of the responsive online book interface were designed and implemented, based on the technical principles of educational interfaces, as stated in section 2.

4.1 Use of Images

For this item, the questions "a) the number of images disrupts cognitive load?" and "c) unnecessary decorative images are used?" must be answered in the design phase of the books, which the authors and the instructional designers are responsible for. They deliver a document called ID (Instructional Design) which will guide the developers of books. In responsive design, the images must be fluid, and therefore the questions "b) are there pictures to illustrate concepts?" and "d) are there texts and images together?" are treated in the framework level.

In the construction of interoperable interfaces, it is important that the images are properly display on all platforms, insofar as their own, most of the time, is part of the learning content [2]. Therefore it is necessary to have good sense to choose the maximum and minimum size that the image should have when resized, and define whether the picture may be hidden or not on a small screen resolution, so that the purpose of using it in the educational resource is not lost.

Below, in Figure 1, it can be seen a case of the behavior of the images from the book in different resolutions, respectively: personal computer (1366x768), tablet (600x1024) and smartphone (480x800):

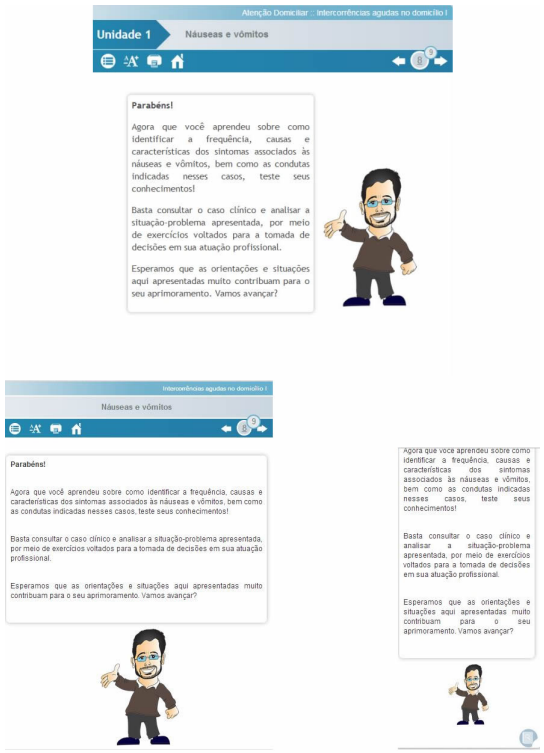

Figure 1: Images from the book in different resolutions

The image used in the example above is essential to illustrate the concept presented, making it more attractive and familiar to the student, through the representation of a human figure presenting the text content. Therefore, it is important to keep that image accompanying the text, regardless of screen resolution. But to achieve the best image presentation with text, some principles were taken into account.

In the original display, on a computer, the image is accompanying the text on the right. The solution used when it comes to tablet resolution was repositioning the image below the text to prevent it and the block of text from shrinking too much when lowering the resolution. This repositioning is done by establishing breakpoints in the CSS file from the framework, with Media Queries. These breakpoints define the changes that occur in the layout, format and positioning of the elements when the screen reaches a certain resolution. The framework establishes its own breakpoints, with rules geared to the purpose of the educational book, applying the pedagogical principles presented. In the example below we see two breakpoints used in the framework:

@media only all and (max-width:699px) /* tablet retrato */ /***<regras css>***/ @media only all and (max-width:480px) /* smartphone retrato */ /***<regras css>***/

Also, is set a minimum size limit for all images from the book, to ensure they do not become too small and unrecognizable during resizing:

conteudo img min-width: 50px

The decision whether an image should be hidden in a small screen resolution must be made by the designers of the book, following the Theory of Cognitive Load. The Theory of Cognitive Load sets that an instructional material stores three types of loads, called intrinsic, relevant and irrelevant. Intrinsic load is connected to the complexity of the teaching material. The relevant charge is promoting new knowledge. Irrelevant load, on the other hand, is one that does not directly relate to the content to be learned, and waste mental resources that could otherwise be utilized [3].

Regarding the interoperability, it is important that in the adaptation of content from one platform to another does not occur increasing of irrelevant cognitive load, or reducing of relevant cognitive load [19]. Thus, instructional designers can make an appointment in the image on ID to guide the developer specifying the minimum horizontal pixel resolution at which the image should be hidden, if it has irrelevant cognitive load. The framework of the book offers specific CSS classes for hiding elements, which are shown in sub-section 4.5, which deals with the layout.

4.2 Texts Presentation

Responding to questions from the homonymous technical aspect in section 2, it was tried to automatically give to the fonts adequate size for reading, according to the screen size, but at the same time offering an accessibility feature that allows students to increase or decrease the size of font to his preference. Paragraphs and other visual elements are presented in a consistent manner and are fluid, increasing or decreasing their size according to the current resolution, always filling the entire screen (see Figures 2 and 3).

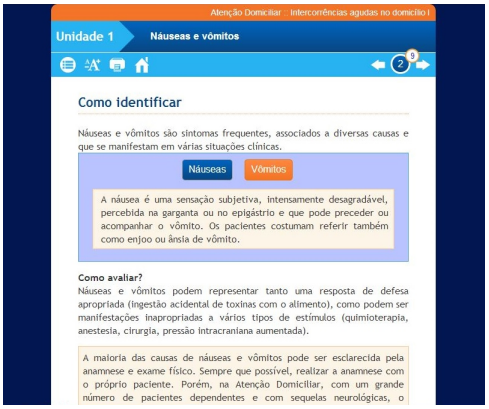

Figure 2: desktop computer (resolution: 1366x768)

4.3 Orientation and Navegation

The production of interfaces for different platforms has the challenge of bringing a sense of sharp orientation to all devices [2]. Analyzing the images (figures 2 and 3), it can be seen that the menu icons are composed of images without text that intuitively suggest what they are for, to properly use the space at various resolutions without losing the mean-

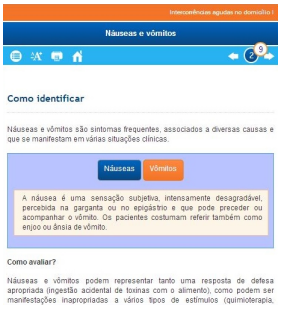

Figure 3: smartphone (resolution: 480x800)

ing. The navigation buttons clearly show the current page, how many pages there are and how to move between pages. The header layout automatically adapts to the change in screen resolution, keeping consistent the identification of the activity currently being developed in the course.

4.4 Interactivity

With regard to the conception of multi-platform educational materials, an adequate interaction design is essential, particularly because the devices can be controlled by different equipment [19]. Each device has different ways of interacting with a web page. On computers, keyboard and mouse are used; on smartphones and tablets a touchscreen interface is used. It is necessary to adapt the ways to interact with the elements of the educational web resource so that the student is able to interact without difficulty in all devices. A special case is the change of the interaction by mouse click to touchscreen. The touchscreen interaction requires a touch area with adequate size for human fingers. Therefore, while resizing icons that represent some function of the educational object, a minimum size limit must be established so to be able to access its functionality through touchscreen without difficulty. According to the figures already presented, all icons of the book have an appropriate size at mobile devices resolutions. The framework provides a wide range of interactive and animated features that respond to the action of the student, to enrich the way of interaction with the content (eg, Figure 4). All these features, called widgets, are responsive, with adaptation rules defined via CSS and javascript. Furthermore, the framework provides some applets, such as questionnaires, quizzes, calculation of BMI (body mass index), etc., supplementary to the study of the book, all with responsive behavior.

4.5 Layout

The entire layout of the book is arranged on a grid system of the the framework. The grid system is a technique used in layouts to organize the content of a page, being a key item in responsive frameworks. The grid system of the book's framework consists of 10 columns, with widths measured in percentage relative to the father element. Every element within the grid system assumes a size proportional to the size of the current block that holds it, thus ensuring the flow according to the screen size.

There are 3 categories of CSS classes to create columns, which determine the relative width of the block according to the type of device: 1. x-size (desktop); 2. x-responsive

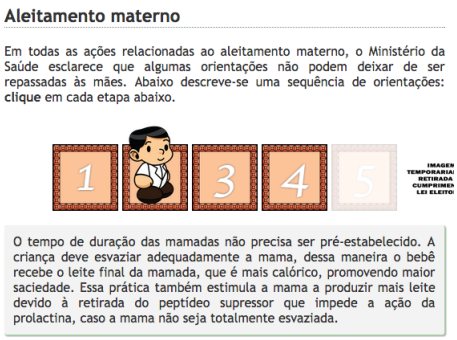

Figure 4: Example of interactive and animated feature

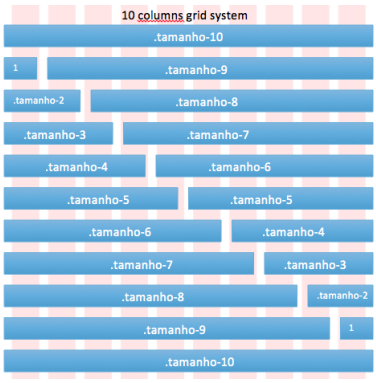

Figure 5: Grid system

size (tablets); 3. x-phone-size (smartphones), where "x" tells what percentage of the width of the container that holds the element is used as the relative width of the element. For example, if one wish a line with two blocks, one with 40 percent size and other with 60 percent, which blocks exchange in size when in a tablet, and that the first block is hidden and the second has 100 percent width when on a smartphone, the html code is this:

Thereby you can freely establish various strategies for resizing, repositioning and hiding elements, according to the purpose of the educational content. The framework provides a standard template for the interface on every page of the book, following the same color scheme, the same style elements such as buttons and links, the same paragraph and lines spacing and the same default font size. It allows the definition of different color schemes for each book, as noted in the examples shown in Figures 1 through 3, using a configuration file. The line and paragraph spacing is proportional to the current font size, and this size can be defined either by resolution of the current screen as the customization of font size by the student.

5. CONCLUSION

This paper brought important requirements according to the guidelines of the Multimedia Learning Theory, with regard to the use of images, texts presentation, orientation and navigation, interactivity and layout of educational objects. In addition, some basic concepts of Responsive Web Design were presented. The main point of this work was to present a responsive online book as a mobile educational object, developed by UNASUS/UFMA. The important characteristics in the implementation of that online book for mobile devices were presented, aiming to contribute with other responsive web design researchers and developers. The proposed mobile web interface proposal makes an adaptation of the content in a way that does not affect the student, regardless of the device's screen resolution.

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