Offline Web Applications: A New Model for blended Learning

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Abstract. Learning environments have changed during the last years mainly because the introduction of new technologies. Technology could be use inside the classrooms to support face-to-face scenarios. But the learning process goes beyond the boundaries of face-to-face tuition. Online learning is an emergent field, opening the door to several kinds of learning modalities, such us Blended Learning. There, face-to-face instruction mixes with e-Learning strategies conforming new scenarios. But there is a gap between these approaches. The transition between the classroom and student's home affects students' outcomes, mainly because students are distracted from the tasks they are working on. Students are interrupted while changing the context between home and the class. To fill this gap, we propose a model that deals with the problematic of using Blended-Learning strategies in disconnected scenarios. The model uses Web Applications to create Blended-Learning without the need of deploying learning content over the Internet, but taken profit of the advantages of the latest web technologies: the HTML5 standard.

1 Introduction

Educational scenarios have incorporated many new course programs within the new century. For several years, technologies have been introduced to create a new ecosystem [1], bringing us new learning experiences. This ecosystem is composed by all the elements that have been traditionally involved in face-to-face tuition in conjunction with technology. This technology allows teachers to create new teaching experiences. A list of emerging formats [2] includes, among others: fully online; blended; face-to-face; video streaming; and courses enhanced with Web 2.0, virtual reality, social networks, mobile devices, and cloud computing. These formats are used both inside and outside the classroom. In the case of e-Learning, it allows institutions to use learning resources inside and/or outside classrooms, since the Internet is present almost everywhere. The wide availability of Internet connections and devices able to use then, let students to continue working outside the classroom. But there are some situations where there is no Internet availability. From isolated areas to natural catastrophes, the assumption of been always connected may not be always true. In some occasions may be a lack of connectivity for a short or long period of time. In other cases the Internet

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connection may be intermittent or limited.

At this point, the definition of new learning environments is needed to take advantage of the introduction of technology within learning environments, but also taking into account the related issues. The interruptions produced in the system due to the lack of connectivity has to be taken into account, as well as the problems related with data synchronization. But it is not only a question of dealing with the problems caused by the interruption of Internet connection. New methodologies can be used to take advantage of the characteristics of Blended Learning. But, the introduction of new technologies, such as one of the major issues when designing learning system [3], require finding a balance between innovation and production. Designing blended learning systems is challenging since, technology is relatively changing, and finding an appropriate balance between innovation and production is difficult.

In this work, we present a Blended Learning model that introduces Web Applications in the game. Through this approach we address the issue of providing Blended Learning in areas where Internet is not available. We manage the problematic of being disconnected in a way that students aren't aware of such us disconnection, helping them to work without an Internet connection at home, as well as providing teachers with means to design new learning experiences.

The paper is organized as follows: first it is presented the state of art, followed by a description of the offline Model for Offline Web Applications. Next, a discussion about the presented model is included. Finally the conclusions and future work.

2 State of the Art

In this chapter are defined the concepts that are the base of the model presented in the article. First are presented e-Learning and Blended learning, as key elements in the proposal. Next are introduced the concept of interruption and Web Applications, introducing the elements needed to develop the proposal.

2.1 e-Learning

The e-Learning approach takes advantage of the benefits that information technologies provide to learning environments. They bring new opportunities in learning environments. But contrary of the general believe of most teachers, distributing knowledge elements through electronic media it is not always enough to take advantage of the e-Learning capabilities. It should not be only focused as a cheap way of distributing resources to a big number of students.

The e-Learning term is widely used, but there are several definitions used to define the same learning experience. Engelbrecht [4] defines it as learning distributed by electronic means, including Internet, intranet, extranet, audio, video, interactive tv and CD-ROM. Meredith et al. [5] refer to the learning provided through the Internet and web technologies. Watanabe [6] defines e-Learning as distant education using Internet and/or other information technologies.

The main characteristics that an e-Learning system has are [7]: it includes utility content for the learning object; it uses instructional methods such as examples and practices to help in the learning process; It uses means, such as words or images, to deliver the content and the methods; It could be conducted by an instructor (synchronous e-Learning) or designed to self-paced study (asynchronous e-Learning); It builds new knowledge and abilities associated to individual learning goals or to improve organizational performance.

When synchronous and asynchronous e-Learning is mixed become to scene what is known as Blended Learning. Graham [8] defines Blended Learning as systems that combine face-to-face instruction with computer-mediated instruction, e-Learning. Face-to-face, Blended Learning and e-Learning are difficult to understand separately, mainly because there are overlaps between then [9]. In Blended Learning, are combined different concepts: from the use of technology to the time spent on online learning. Blended Learning is located between face-to-face and Online modalities. Sometimes it is difficult to clearly separate them. Blended Learning scenarios have pedagogical implications, as described by Wang [10]. For effective interaction in both online and offline settings, instructors should take account of students' characteristics and their technical and learning competencies. Technical issues include the necessity of a reliable and robust infrastructure to deliver courses over the Internet [11]. Moskal, also asserts that an initial blended learning strategy might consist of the answers to a set of questions for setting up the environment.

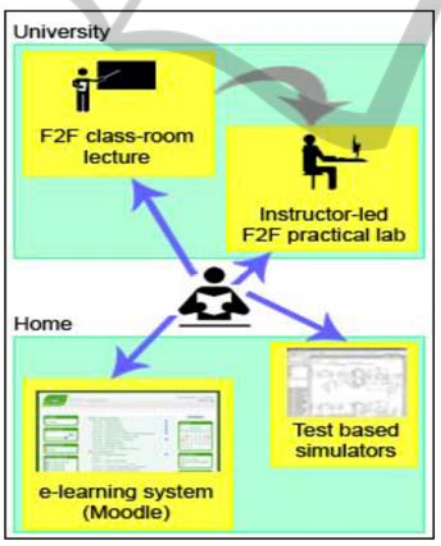

Fig. 1. Blended Learning process in Khan's model.

Khan proposed a Blended Learning model in education [3], as depicted in Fig. 1. In this model are described four processes: 1) Students can study basic course in Face-to-Face (F2F) lecture at university; 2) Students can implement the practical part of lecture in the lab; 3) Instructor can give lecture and additional learning contents via e-Learning environment; 4) The practical part of the lecture can be simulated and

available via e-Learning environment. In this process there are two separated spaces: the classroom and student's home. This process has been designed through the assumption of a permanent link to Internet at students' home. But, what happen if there isn't Internet connection there? How will the process be affected when it is interrupted by a lack of connectivity?

2.2 Interruptions

McFarlane [12,13] proposed a general, interdisciplinary, theory-based definition of human interruption, which says that human interruption is "the process of coordinating abrupt changes in people's activities." According to Trafton and Monk [14], interruptions occur when a person is working on a primary task (usually long-lasting) and an alert for a secondary task occurs. An important aspect of alerts is that they create an interruption lag as the user has to turn their attention to the interruption. The person then starts the secondary task. After completing it, the person must resume the primary task. During the resumption lag, the person must figure out what they were doing during the primary task and what to do next.

2.3 Web Applications

HTML5 is the latest version of the HTML standard. One of the new ideas present in the web development on these days is a set of specifications known as Web Applications. The goal of this specification is to enable improved client-side application development on the Web, including specifications both for application programming interfaces (APIs) for client-side development and for markup vocabularies for describing and controlling client-side application behavior.

Due to the variety of scenarios where Web Applications can be used, new ways are needed to support the development of applications. One of the aspects to take into account is the network connection availability or the interruptions while using Web Applications. In order to enable users to continue interacting with Web Applications and documents even when their network connection is unavailable - for instance, because they are traveling outside of their ISP's coverage area - authors can provide a manifest which lists the files that are needed for the Web application to work offline and which causes the user's browser to keep a copy of the files for use offline Web Applications. These technologies are called Application Cache[1]. Using these technologies, it is possible to overcome the constraint of been always connected to use the web.

Other set of technologies allows Web Applications to store locally information. Keeping a copy of files using in Web Applications is not always enough to make

[1] Offline Web applications. Available at: http://www.whatwg.org/specs/web-apps/current-work/#offline. Date accessed: 01 Apr. 2013.

them interruptions resilient. Webstorage[2] introduces two related mechanisms for storing
name-value pairs on the client side: local and session storage.

3 Web Applications within b-Learning

As aforementioned, Blended Learning is the result of mixing traditional face-to-face teaching techniques with e-Learning. Face-to-face takes place within the classroom, and even though in some cases technology is used, the teacher is present to guide students. Since e-Learning takes place outside the classroom it is not enough delivering the same content through Internet. This content must be adapted to the requirements of these environments. Furthermore, there are situations where there is not such us Internet availability. On these situations, the delivery of Blended Learning it is not possible using Internet. Students may not be able to access the content since they don't have a connection to the institution's servers.

3.1 Designing Web Applications for Offline Operation

It is at this point where the utilization of Web Applications may help us to overcome these problems. The offline Web Applications let us to replicate content accessed for late use, when the Internet connection were not available. This feature allows students to consume resources when the Internet connection is not available. But the simple replication of this content is not a guarantee of success on e-Learning. The content for online scenario may not be the same as the content for offline use. This means that the content must be adapted or transformed while the student is interrupted.

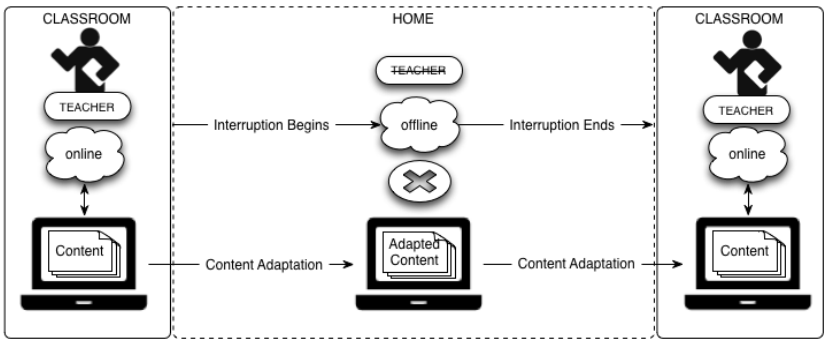

Fig. 2. Dealing with interruptions in Blended Learning environment.

The Fig. 2 shows the process to deal with interruptions in Blended Learning environments. In this scenario there are two main elements: the classroom, where face-to-face tuition takes place and home, where students perform the offline activities. When

[2] WebApps Working Group. Available at: http://www.w3.org/2008/webapps/. Date accessed: 01 Apr. 2013.

students are in the classroom, the content is used in conjunction to the guidance of the teacher. Students have access to the Internet and they may use the available contents. This creates an environment mostly different from the one at student's home. There, students have to deal with the learning units without the guidance of the teacher. As a result, content must be adapted when the student is offline. This content adaptation is produced when the interruption overcomes. This content adaptation allows students to work with the material according to the new scenario.

To allow Web Applications to store content in order to be retrieved for offline operation first of all must be defined the policies to operate when the interruption overcomes. This interruption is caused by the lack of connection to Internet. Therefore, the web server where the content is located will not be accessible. Content will be retrieved depending of the site status. If the site is online, the content will be fetched from the site web server. In the other hand, if the site status is offline, the content will be fetched from the Local Cache.

When the Web Application is used when there is a connection to the Web Server, it has to perform some operations in order to store locally the content. We need to define the storage places where local information will be located. Web applications include several technologies for storing locally information, as aforementioned. Application cache allows us to store all the resources that compose the content, for late retrieval. Web Server stores the content for consuming when online, meanwhile the Local Cache is used for offline operation. The local cache is composed by several related technologies. We use two of them to deal with the problem of consuming offline resources. They have been selected for been the most effective and simple to use for this task. The first element is the Application Cache. There are stored all the resources that compose the content. These resources are the HTML pages, as well as all the images, text, video and any file that is included within the HTML page. The second storage element is the Local Storage. It allows storing and retrieving information in a key-value format. In the Local Storage, information about stored elements and the actions performed when online and offline use is managed. This information is not only useful as a caching mechanism. It is also used to store policies about the content management as well as to store offline work for later synchronization with the Web Server.

The Web Application works both in online and offline mode. Depending of the connection status and the rules for displaying content, the content may be transformed. This process occurs after the browser requests the content and before the content is visualized in the browser. The content transformation process translates the request, presenting in the web browser the corresponding content.

3.2 Offline Model for blended Learning

There is an issue that has been neglected when modeling Web Applications: how the application behaves when it is interrupted and how to recover from interrupted work. Furthermore, there is no clear proposal about how to use Web Applications in Blended Learning environments. The proposed model approach allows creating Blended Learning environments. It provides means to overcome the problems related with adapting content from face-to-face tuition to online learning.

The proposed model represents the static properties of a web site, as well as it behavior. The static properties define the structure of the web site. The behavior defines how the system will react to the events and how it will change over the time.

Basic Elements. Web pages are the basic elements in the *World Wide Web*. They are also the basic elements in the Web Application model. They are defined as nodes. A node is an element in the model that may be connected to other nodes. They are connected to each other to conform what is known as web projects. A web project is a superset of nodes and it is the upper level of abstraction in the model. We can refer web projects as web sites. Within learning environments, projects represent the concept of lessons. Teachers can deliver the information that will be used in the classroom to support his dissertation or the work to be done at home. These lessons are composed by topics. These topics are represented in the Web Application model by nodes.

Properties of the Model. The model shows both the static properties as well as the behavior of the projects. To represent these properties, nodes have associated properties, represented as node states. We propose three state levels for nodes: ***static***, ***navigational*** and ***data***. Static state is defined according to the requirements of the site. Static states are *normal*, *ondemand*, *precacheable*, *nocacheable*, *initial* and *external*. Navigational state changes over the time when users use the web site. Navigational states are *novisited*, *visited* and *selected*. Data states are the result of the combination of the two previous states. Possible values for data states are *cached* and *nocached*. Next are described in detail these properties.

Static states are defined to answer the following questions. The first question is: is the node *internal* or *external*? *External* nodes are out of our Web Application, but may exist some link to it. At the contrary, *internal* nodes belong to the Web Application. External state excludes other static states for the node. The second question is: is the node initial? *Initial* node is set to *initial* state. It will be always accessible in offline mode and *precacheable*. Also, *initial* nodes are unique within the web project. *Initial* nodes are like the index page within the Web Application. The third question is: will be the node cached when the web site is visited? *Precacheable* nodes will be always cached when the web site is visited, but *nocacheable* nodes will not be cached ever. *Normal* nodes will be cached when the user visits it, meanwhile *ondemand* nodes will be cached only when users explicitly make an action to store it.

In Blended Learning environments, static states help teachers to design Web Applications for e-Learning. Through them, they may set a web page as an entry point for the unit, the *initial* node, which will be always available for the students. Also, the other states define web pages that will not be ever available for offline use (*node-nocacheable*), web pages that will be always available for students (*node-precacheable*), web pages that will be available only when the student show them (*node-normal*) and web pages that will be available when the student request them explicitly (*node-ondemand*). With these features it is possible to design a learning experience that goes beyond the classroom and, at the same time, do not force students to perform any special action out of the e-Learning unit, such us store manually content for late use.

Navigational state is set when users navigate through the site. It changes while the site is used. It is a dynamic state. In the model have been defined three states: *novisited*, *visited* and *selected*. The question answered with this state is: has been the node visited and/or selected? When a node has been visited, it is set to *visited*. If the user makes an explicit action to store the node, it is set to *selected*. Meanwhile, if the node has not been visited it is set to *novisited*. In Blended Learning environments, this feature could be used to engage students on working in the classroom. This could be done designing the learning units in a way that they need to visit web pages or select some of them explicitly in order to work with them later at home. This state may be also used to analyze the activity of the student on the Web Application.

Data state is the result of the combination of the two previous states. As a result, a node can be *cached* or *nocached*. When a node is *cached*, it will be available when the site is interrupted. When a node is *nocached*, it wouldn't be available when the site is interrupted.

Content Transformation. The model introduces means to deal with interruptions due to offline navigation. One of the mechanisms used to support offline navigation is the transformation of the elements of web pages. These transformations may act removing or altering the content of web pages. Available transformations are element disabling and alternative link destinations.

Element disabling allows removing elements from web pages. When using web pages, some of the elements may not be available for users in offline mode. This restriction may be due to several reasons. One of the reasons could be that part of the web page requires a connection with some external resource. Since that there is no connection to the server, the element wouldn't work. An example of this scenario is when a form is used to send information to a remote server. Other scenario is when linking to an external resource. Because the site is in offline mode, the action couldn't be performed. Another reason for disabling an element is when it shows information retrieved from an external server. An example of this scenario is when using web pages to show online maps, *Facebook* walls, recent tweets or advises from external sources. To overcome these situations, the model allows element disabling. Through this technique, any element in the web page could be disabled, preventing it to be presented in the web page when it is in offline mode. Due to the fact that web pages are described in HTML and most elements can be nested, when disabling an element, all the elements enclosed within this element will be disabled to. In Blended Learning environments, this feature could be used to make some content only available when students are in the classroom, disabling it when they are at home.

Another available transformation is the ***alternative link destination***. When using the web in offline mode, some of the destination will not be reachable due to a lack of connectivity or for design constraints. Also, this feature allows to present alternative content for offline operation. To prevent the problems associated with the lack of connectivity and to support the design constraints, the model allows giving an alternative destination to any link in web pages. As a result, when in offline mode, alternative links will work instead of the original. In Blended Learning environments, this feature could be used to present alternative contents to the student, depending of the learning context.

4 Discussion

The presented offline Web Application model introduces features to design Blended-Learning scenarios upon certain characteristics. In order to define the Blended-Learning strategy to follow using the model, we have asked the most relevant questions stated by Moskal [11]. We also discuss how this model can help to introduce Blended-Learning using the model. Some institutions want to introduce Blended Learnig, but they have problems related with the infrastructure. This infrastructure may be a problem from two points of view. Firstly, the institution needs to have a server or servers visible over the Internet, with the involved costs in time and resources. Secondly, students also need access to the Internet to consume the online courses. With the proposed model there is no need for that infrastructure. It is only needed a simple web server within the institution and an access point for the students and teachers, such as a wifi access point. This infrastructure is simpler and cheaper than the one over the Internet. Students will also improve their performance because they only need to access to one place, the Web Application, regardless the place where they are located on, in the classroom or at home. Furthermore, they don't need to synchronize the work between home and school. The proposed model is designed to synchronize it automatically. The Blended Learning process model presented by Khan's [3], as depicted in the Fig. 1, is also applicable with our model. The offline Web Application model supports the elements presented, combining in the same application the material to support face-to-face activities, as well as the work at home. But our model includes the means to overcome the problems related with the lack of connection to Internet. It provides content adaptation to transform the e-Learning material to the learning environment where the student is located on each moment.

5 Conclusions

In this paper has been presented an offline Web Application model that deals with the problematic of providing Blended Learning on disconnected environments. The proposed model includes means to design the learning content for been automatically adapted from face-to-face tuition to offline scenarios, making it possible Blended Learning using Web Applications. Available transformations prepare the content for been displayed according the rules defined by the teacher. As a result, the creation of Blended Learning scenarios is simplified. From the infrastructural point of view, the implementation of Blended Learning using this model is simpler and cheaper than the deployment of learning content over the Internet, despite of the advantages related with the facilities provided for consuming Web Applications without an Internet connection. Also, the adoption of the HTML5 standard allows the model to be used in every standard compliant browser and makes it platform independent. With this work we have state the bases for the future development of Blended Learning strategies using offline Web Applications. As a future work, the design of tools that support the model will allow to test the outcomes using this model.

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