Designing the CloudBoard: an innovative tool for collaborative e-learning environments using HTML5

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Abstract. This paper aims to summarize the concepts of e-learning, LMS/VLE and cloud-based computing and present how the use of these technologies trends towards collaboration and interactive multimedia. Another purpose is to define and explain this trend in e-learning environments and technologies by presenting research grounded in constructivist learning theory. Subsequently, this paper summarizes the current situation of online whiteboard tools and the new HTML5 standard and key attributes. Next, this paper outlines how an open HTML5 solution for a collaborative, cloud-based, online whiteboard can improve accessibility, performance, collaboration, and security plus offer enhanced multimedia opportunities. Finally, this paper concludes with a presentation of an early prototype of an open, cloud-based online whiteboard, an e-learning cloudboard, which utilizes the advancements found in HTML5 and modern JavaScript libraries such as JQuery.

Keywords: LMS, HTML5, Distance Learning, E-Learning, Cloud Collaboration, Online Whiteboard, Educational Technologies

1 Introduction

Rapid technological advances in web technologies is something we have become accustomed to over the years, as the WWW has evolved and matured into what it is today. However, the changes in how the WWW is built can be argued to constitute an advancement of a greater magnitude with the introduction of HTML5, the new markup language from W3C (www.w3.org). HTML5 enables designers to create innovative ways of interaction between users and between users and systems not possible before. Furthermore, the new open standard combined with powerful JavaScript libraries also gives designers a platform to develop user interfaces not possible until now.

This paper will operate in the intersection between technology and education, exploring HTML5 and how it can support development of educational technology. More specifically, we will create a prototype of a collaborative e-learning tool using HTML5 and various JavaScript libraries demonstrating the possibilities of the new technology.

The following section will begin by elaborating on research on educational technologies and follow with a background into the constructivist view on learning as a social construction, implying the need for educational
technologies to incorporate rich, sound support for interaction between users. Finally, the paper gives an overview of existing collaborative tools, describes the relevant attributes of HTML5 in detail and concludes with a description of the prototype called the CloudBoard.

2 E-learning, cloud computing and content

El-Bakry and Mastorakis state that LMS (Learning Management System) /VLE (Virtual Learning Environment) are the primary tools used to implement e-learning [1]. Furthermore, according to El-Bakry and Mastorakis [1] LMS/VLE are different acronyms for the same concept. LMS/VLE are variations of CMS (Content Management Systems) where the focus is on learning. E-learning can be defined in a variety of ways, but in this paper the focus is on e-learning using the broad definition found in previous research. Zhang and Nunamaker define e-learning as “any type of learning situation when instructional content is delivered electronically via the Internet when and where people need it” [2] and Welsh provides a similar definition stating that “E-learning can be defined as the use of computer network technology, primarily over an intranet or through the Internet, to deliver information and instruction to individuals” [3]. Finally Koohang and Harmon [4] reinforce this definition stating “e-learning is the delivery of education (all activities relevant to instructing, teaching, and learning) through various electronic media.” In other words, e-learning is where learning activities take place online and use technology. In summary, e-learning is then a broad term defining the digital consumption of learning content over the Internet in some form of LMS/VLE.

E-learning has grown and changed substantially since the advent of the Internet and the World Wide Web and is one of the fastest growing trends involving technology and education, especially in higher education [5][6][7]. Taylor’s conceptual framework that describes the evolutionary development of distance education [8] describes how e-learning has grown through different phases into his final 5th stage that emphasizes key aspects such as computer mediated communication and online interactive multimedia. Furthermore, in recent years, e-learning has been shown to consist of collaborative communication and interactive multimedia just as predicted by Taylor [6][9]. In addition, Zhang et al. [10] finds that it is not only sufficient to involve video in e-learning environments to achieve favorable learning outcomes. Positive learning outcomes are contingent on video interactivity. Furthermore, the trend is toward interactive multimedia content and collaboration.

Cloud computing and cloud collaboration are two other concepts that can be integrated into a modern interpretation of e-learning and the use of LMS/VLE. Hayes defines cloud computing as software where the major components reside on unseen computers scattered about the Internet. He names popular software such as Google Docs as examples but even states that “for most applications, the entire user interface resides inside a single window in a Web browser” [11]. Erickson further narrows the concept of cloud computing to that of cloud-based collaboration [12]. He states that cloud-collaboration is on the rise and that there is a shift from applications to solutions in the cloud where collaboration and content are in focus. Correspondingly, he states that cloud collaboration will take place in the web browser using a rich interface for
multimedia rich content. These ideas correspond to the current delivery mode of e-learning which is via the Internet and the World Wide Web and subsequently primarily web browser based.

3 Constructivism and Instructional Design

Given that e-learning uses LMS/VLE, which are based in the cloud and contain multimedia content, how do we then maximize the instructional design of a collaborative cloud-based tool? As defined by Willis [13] “instructional design is the technology for the development of learning experiences and environments which promote the acquisition of specific knowledge and skill by students”. Instructional design in e-learning then deals with the design of the e-learning environment to promote learning. The next step is to base this instructional design on some form of existing learning theory. Fortunately, a great deal of previous research already exists that discusses this very topic. A variety of researchers in the disciplines of e-learning and constructivism emphasize the importance of and point out the beneficial aspects of using constructivism to design e-learning artifacts and environments [14][4][5][15][16][17][9]. Additionally, the constructivist learning model is the most commonly adopted in e-learning [9]. The basic tenet in existing research is that Vygotsky’s fundamental theories regarding social constructivism can be utilized for the instructional design of e-learning environments and content in order to maximize learning outcomes. Tam [17] reinforces this concept by stating that “Vygotsky’s theory of social constructivism, as opposed to Piaget’s individualistic approach to constructivism, emphasizes the interaction of learners with others in cognitive development”. Tam [17] elaborates on how constructivist principles are key in a technology-driven collaborative environment, especially for e-learning situations by stating that “Constructivist principles provide a set of guiding principles to help designers and instructors create learner-centred, technology-supported collaborative environments that support reflective and experiential processes. When applied to the distance learning context, there is no doubt that constructivism and the use of new technologies will help transform significantly the way distance education should be conducted”. Finally Snyder [16] concisely summarizes constructivism and e-learning environments by stating that “constructivism supports learner-centered environments that are authentic, collaborative, constructive, and active”.

A key recurring theme in the research regarding e-learning, instructional design and constructivism is that the environment as well as the content must be interactive. Beldarrain [14] states that instructional design must be adapted for a focus on interaction saying, “Instructional design frameworks must be adapted to purposely integrate student interaction using technology tools”. Tam [17] emphasizes the importance of social interaction when she states “The constructivist perspective supports that learners learn through interaction with others. Learners work together as peers, applying their combined knowledge to the solution of the problem.” Furthermore, Moore [15] defines three types of interaction in learning: learner–instructor, learner–learner, and learner–content. Moore [15] explains that all three forms are important, but that learner-learner is especially important and easier to realize in a multimedia e-learning environment than in large face-to-face groups. Zhang [9] succinctly summarize the importance of social interaction stating “Learner-learner interaction fosters
collaborative learning”. The need for interaction even extends outside of the intrapersonal interaction to interaction with the instructional content. Zhang et al. [10] reinforce this idea when they conclude in a study of interactive video in e-learning that interactive video and individual control over the content can improve learning outcomes. Finally, Beldarrain [14] mentions how emerging technologies not only allow content to be customized but even customizable interaction where the learner can determine how and when interaction takes place.

4 Current online collaborative tools

The need for an online collaborative environment has not gone unnoticed. There are a variety of products available for purchase or free use. The existing products vary in capabilities, price and implementation technologies. The common name for these products seems to be Online WhiteBoards [18]. The table in Table 1 presents a list of popular products within this field and the list is in no way exhaustive or ranked in anyway. The list is simply intended to provide a glimpse into certain characteristics of current products.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Website</th>
<th>Open Source</th>
<th>Support for all media types</th>
<th>Technique used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twiddla</td>
<td><a href="http://www.twiddla.com">www.twiddla.com</a></td>
<td>No</td>
<td>No</td>
<td>HTML, ASP.NET, JavaScript</td>
</tr>
<tr>
<td>Scriblink</td>
<td><a href="http://www.scriblink.com">www.scriblink.com</a></td>
<td>No</td>
<td>No</td>
<td>Java</td>
</tr>
<tr>
<td>Dabbleboard</td>
<td><a href="http://www.dabbleboard.com">www.dabbleboard.com</a></td>
<td>No</td>
<td>No</td>
<td>Flash</td>
</tr>
<tr>
<td>Groupboard</td>
<td><a href="http://www.groupboard.com">www.groupboard.com</a></td>
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<td>No</td>
<td>Java</td>
</tr>
<tr>
<td>Skrbl</td>
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<td>N/A</td>
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<tr>
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<td>N/A</td>
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<tr>
<td>ImaginationCubed</td>
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<td>No</td>
<td>No</td>
<td>Flash</td>
</tr>
</tbody>
</table>

Table 1- Overview of online whiteboards

The Online WhiteBoard products in Table 1 share a number of characteristics. All of the products are proprietary in some manner meaning that the source code is unavailable. Most offer a free version or trial version with limited functionality and the full versions typically require paying a license fee. Furthermore, the majority use plug-ins in the web browser, i.e. Java and Adobe Flash. Despite the fact that different web browsers deal with plugins differently,
the use of plug-ins is a large security risk for browsers because security holes in plugins can create a situation where interaction with the host operating system becomes possible [19]. A recent study by the security company Qualys shows that out of date plugins for Java, Adobe Reader and Adobe Flash provide a high percentage of exploits [20]. Also, the products typically focus on drawing and image uploads. Some products contain some form of chat solution. None of the products support video or interaction with video and none of the products explicitly focus on learning. The typical focus of the products is on drawing, conferencing and sharing and collaborative creation of simple content.

5 An E-Learning CloudBoard with HTML5

If the aforementioned principles of instructional design, constructivism and e-learning are to be utilized then an E-Learning CloudBoard should contain certain characteristics. The proposed CloudBoard should be open, secure, responsive and interactive. The next step is to use the appropriate technologies to achieve these design goals. Fortuitously, the new, open standard HTML5 from W3C contains the capabilities to create a new innovative E-Learning CloudBoard.

5.1 New tools for online collaboration

HTML5 is the impending official standard from W3C (www.w3.org), which is the official, non-profit organization that creates and maintains various web standards. The W3C establishes the various web standards through vote and discussion by the member organizations that include the majority of leading IT organizations http://www.w3.org/Consortium/Member/List HTML5 is currently a W3C Editor’s Draft. This means that HTML5 is currently not a W3C recommendation and therefore not an official web standard yet, however, this standard makes revolutionary changes in how HTML can be implemented in the web browser. Though full compliance for HTML5 does not currently exist and compliance in legacy browsers is more or less non-existent, support by the leading web browser manufacturers such as Microsoft, Apple, Mozilla, Google, Opera, etc. in their respective browsers is considerable and increasing with each new version [21]. The working draft was originally planned to become an official W3C recommendation by the fall of 2010, but the date has since been adjusted to 2012 [22]. HTML5 along with the new JavaScript APIs (Application Programming Interfaces) offer web developers new native tools to create safe, interactive, responsive and collaborative online environments. These web tools quite simply represent a technical revolution in web development.

The following lists provide insights into how specific attributes of HTML5 and the new JavaScript APIs can provide the tools needed to create a collaborative e-learning CloudBoard [23].

5.2 Interaction and Multimedia

• Audio and Video tags - HTML5 provides native support for audio and video. These new HTML5 tags allow for audio and video to be directly played by the web browser without a need for any form of third party plug-in.

• Canvas – HTML5 implements a new canvas tag that allows for web applications to draw 2D graphics. With the canvas tag areas of a web page or
even an entire web page can be drawn. Even video can be presented as a canvas and manipulated as desired.

- WebGL – Is a standard for programming in 3D when using the web browser as a platform. WebGL is an interface between JavaScript and OpenGL, which allows for hardware accelerated 3D rendering using the HTML5 canvas tag.

- HTML5 is natively user editable – HTML5 has the attributes designMode and contentEditable. These attributes allow for native editing of the associated objects directly by the user in the web browser.

5.3 Communication

- Web Sockets and SSE – Web sockets is a portion of the HTML5 standard that represents the next evolution in web communication. Web sockets resemble the Web 2.0 techniques of AJAX and Comet in that direct communication that is bi-directional (full duplex) between the client web browser and the server are possible thus avoiding the need to update an entire web page via an HTTP request. In other words, when data changes on the web server, the web server can send a request to the client, eliminating the need for polling and providing a true, real-time exchange of information from the server to the client web browser.

- Cross Document Messaging – HTML5 allows web browser frames, tabs and windows from different origins to communicate securely and directly with one another [24]

- Geolocation - By using the new JavaScript Geolocation API, web applications can reveal a client’s physical location as well as show where other users currently are. This process can only be done with the user’s permission.

5.4 Performance

- Web Workers – Web workers allows JavaScript code to be executed in parallel without affecting the user interface. This implementation allows web applications to perform multiple tasks simultaneously therewith improving the performance and responsiveness of HTML5 web applications. In other words, web applications can now support parallel processing and more calculation intensive implementations.

HTML5 can utilize the aforementioned attributes to create a collaborative e-learning environment that is accessible, responsive, secure, collaborative, multimedia-rich and interactive. Furthermore, as previously stated, HTML5 provides the tools to implement the aforementioned instructional design characteristics and constructivist principles needed for a collaborative, interactive environment.

6 Presenting the CloudBoard

The CloudBoard builds on the concept of a whiteboard (see Fig. 1). The whiteboard takes up most of the space in the browser window and is the part of the system where all interaction between participants takes place as well as all
the different types of objects such as text, links, different types of media and Twitter feeds. The whiteboard itself is dynamically resizeable facilitating both small and large projects as well as big or small screens. The “Control Panel” is located on top of the whiteboard space. The control panel is always on top and always accessible for the user, no matter what part of the whiteboard the user is viewing and features functions such as login/logout and a time slider elaborated on later in this text.

Fig. 1. The CloudBoard prototype

The whiteboard view is shared between the users of the system, and what you see is exactly the same as everyone else sees. Further, all users have the same privileges, and everyone can edit and delete any object in the CloudBoard. These features of the CloudBoard will now be elaborated on following the themes outlined in the previous section, i.e. “accessibility”, “responsiveness”, “security”, “collaboration”, “interaction” and “multimedia”.

6.1 Accessibility

The characteristic of accessibility refers to the idea that the entire environment is open and accessible for everyone. Furthermore, this concept focuses on the openness of the actual technology. In the case of HTML5 the standard and all associated technologies such as JavaScript and CSS3 are open. Therefore, by building an E-Learning CloudBoard exclusively with HTML5 the codebase will be free from proprietary interests. Furthermore, the actual code can even be made open source to further expand upon the concept of accessibility and openness in education and e-learning. By not relying on third-party plugins and proprietary code, we also ensure that the CloudBoard can be used on computers in environments where the installation of software is prohibited.

6.2 Responsiveness

The attribute of responsiveness refers to the idea that the web application that hosts an E-Learning CloudBoard must be responsive. Inline with aforementioned research, a collaborative e-learning should be online, cloud-based and be leveraged as a web application in a web browser. The
performance of web applications in the web browsers can be a source of frustration for users as simply waiting on webpages to download causes user dissatisfaction [25] and the constant focus on web page rendering and JavaScript rendering performance by the major web browser vendors attests to the need for web applications that are as responsive as desktop applications. The Web Worker attribute in HTML5 addresses this issue directly. By designing an e-learning cloudboard with web workers, the CloudBoard can be multi-threaded just like a desktop application. In that way the user interface will not freeze while performing simultaneous requests from the user. Moreover, the user can perform tasks asynchronously and thereby maximize interactivity with other users and the content. Web Sockets can even improve responsiveness by making chat functions and other forms of communication in a collaborative environment even more responsive due to the ability to send data full-duplex in real-time between the web browser and the server.

6.3 Security

Security is an important characteristic of any computer application but it is especially important for a web application where anyone with a web browser can access the application. By building an e-learning cloudboard entirely with HTML5 without the use of 3rd party plug-ins security can then be managed by the web browser. The web browser is then solely responsible for the rendering of the HTML tags and JavaScript. Updates to the web browser will keep a web application secure as possible and there is no reliance on updates for plug-ins.

6.4 Collaboration

In the area of collaboration, HTML5 offers a variety of new tags and functionality that provide the necessary tools to create a truly collaborative and innovative environment. By utilizing Web Sockets and SSE (Server Sent Events) an e-learning cloudboard can be a truly collaborative environment. Web Sockets and SSE can provide a full-duplex connection between the web browser and the server, so that the exchange of for example text, images, audio and video can take place quickly, efficiently and synchronously across browser windows. Cross Document Messaging makes it both safe and easy to move objects and information between portions of the user interface as well as between the underlying iframes or even between domains. Also, Geolocation offers exciting possibilities to easily integrate mapping technology into the collaborative environment and even make possible collaboration in the physical world by being able to easily show the location of each user, given the user’s permission of course.

All users of the CloudBoard have the same privileges to add, edit or delete objects on the CloudBoard. Since this enables anyone to “sabotage” the information on the CloudBoard, all events is logged and visible to all, thus making individual actions transparent to other users. To minimize the consequences of an accidental edit or deletion of an object, the CloudBoard also incorporates a dimension of time. The time slider in the control panel enables users to view an historical representation of the CloudBoard by dragging the slider control. It also enables users to go back in time and re-activate a deleted object, making it available to everyone again.

6.5 Interaction
As previously stated, the central principles of constructivism, as the name implies, deal with the concepts of constructing knowledge through interaction with the content and other users. HTML5 delivers a variety of new technologies that enable the construction of a truly interactive e-learning environment. The canvas tag is the most important new aspect of the HTML5 standard. The canvas tag gives the user the ability to manipulate a 2D drawing surface natively in the web browser without using any 3rd party plug-ins. Users can create any form of 2D object such as drawings, text or images and even freely interact with them by using JavaScript. Additionally, HTML5 supports drag and drop natively so that users can use a web application just as they would use a desktop application. In the CloudBoard, users can drag and drop for example documents, images, audio and video directly into the collaborative environment. Further, objects can be re-arranged and resized, grouped, merged and connected together.

Finally, the attributes of contentEditable and designMode in HTML5 make it possible for the user to directly interact with the collaborative environment itself (within developer constraints). This gives the users greater learning flexibility by providing the possibility to interact with the environment itself and alter it according to individual preferences. This ability further reinforces the ideals of constructivism.

6.6 Multimedia

A key aspect that separates the possibilities of HTML5 from the other Online WhiteBoard solutions is the ability to natively support and implement multimedia in an a collaborative e-learning environment. The audio and video tags in HTML5 give the user the ability to directly import and manipulate audio and video files. Another exciting and interesting possibility in HTML5 is WebGL. WebGL offers the ability to present and manipulate 3D objects and even entire virtual environments natively within the web browser. These capabilities are entirely inline with aforementioned research in that multimedia such as video is both interactive and collaborative. Furthermore, users can construct their own meaning and knowledge by manipulating the various multimedia objects as desired. Being a cloud-based system, a large number of third-party APIs is also utilized enabling users to easily access for example a Vimeo video or a Twitter feed.

7 Conclusion

The true potential of using HTML5 to create an e-learning collaborative environment that fulfills all the aforementioned characteristics of accessibility, responsiveness, security, collaboration, multimedia-rich and interaction lies in the ability to combine the various attributes. A combination of web workers, web sockets, canvas and native multimedia provides the user with powerful and innovative tools to achieve new levels of collaboration and interaction. This statement is reinforced by Snyder [16] who calls for further research asking for exploratory research into what type of web tools should be used for collaborative learning online. This paper acts on this call for further research by presenting an early version of an e-learning CloudBoard prototype implemented.
with the entirely open and native techniques of HTML5 and JavaScript libraries such as jQuery.

The next step in this research is to deploy the CloudBoard in an educational setting. We will conduct a series of interviews as well as an observational study to reveal how well the CloudBoard supports collaboration in a learning setting.

References