The future of e-learning: interaction, collaboration and individualization with HTML5

Abstract: The aim of this paper is to explore how e-learning can be delivered and consumed in the future using new technologies. First, this paper presents the current state of e-learning and then discusses various issues and problems with e-learning environments. Then, this paper explains HTML5 and related web standards and technologies and argues as to how HTML5 in combination with other modern web technologies such as jQuery and CSS3 can be used to enhance and enrich e-learning environments. Next, this paper defines key themes of an e-learning environment such as, collaboration, interaction, individualization, updated relevant content, performance, device ubiquity, and poor completion rates and explains how specific attributes of HTML5 and related technologies can enhance these themes. Finally, this paper concludes with suggestions for future designs of e-learning environments and calls for using the innovative attributes of HTML5 to create a truly interactive, dynamic, and collaborative e-learning web application.

Keywords: LMS, HTML5, Mass Collaboration, Individualization, Interaction, e-learning, distance learning

Introduction

Rapid technological advances in web technologies have become commonplace over the past 20 years and the pace of change does not seem to be slowing. Furthermore, one of the greatest revolutions since the introduction of the World Wide Web and HTML is taking place with the introduction of a new web standard by the official web standards organization W3C (www.w3.org). This new standard and “revolution” is HTML5 and it allows web designers and developers to create innovative ways of interaction, collaboration and individualization to create web applications and not web pages. Furthermore, the new open standard of HTML5 combined with powerful JavaScript APIs and libraries such as JQuery further enhance the possibilities to erase the boundaries between a web application and a desktop application. This paper focuses on the juncture of technology and education, exploring how HTML5 and related technologies can support the development and improvement of e-learning.

There are a variety of issues with online learning environments that inhibit e-learning from being perceived as equivalent or even better than traditional classroom learning. The central idea behind this paper is to deliberate on future developments of e-learning. A key change in future e-learning environments is based on the precept of removing the administrative portions of an LMS to create an e-learning environment that solely focuses on learning (Jobe, 2011). A traditional LMS can take care of all the necessary administrative tasks related to learning in a formal learning environment. This separation also makes it possible to use the same e-learning environment and content for formal and informal learning i.e. traditional school learning and self-learning/self-directed learning.

The following section will begin by defining educational and technological terms such as e-learning and LMS. Then the ideas of constructivism, learning as a social construction, and instructional design are presented in relation to e-learning. Thereafter, this paper highlights crucial concerns with e-learning and summarizes key aspects of the new HTML5 standard. Finally, this paper points out the specific areas in which HTML5 can contribute to alleviate the apparent problems with e-learning.

E-learning

E-learning can be defined in a variety of ways, but in this paper the focus is on e-learning using the general definition found in previous research. Nichols (2003) provides a thorough definition of the various terms regarding the intersection of technology and education. Nichols (2003) defines e-learning as any web-based technology used for educational purposes and that an LMS (Learning Management System) is an administrative interface that uses e-learning tools to deliver online educational courses. Zhang and Nunamaker (2003) similarly define e-learning as “any type of learning situation when instructional content is delivered electronically via the Internet when and where people need it” and Welsh (2003) provides a comparable 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”. Finally Koohang and Harmon (2005) reinforce this definition stating that “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. El-Bakry and Mastorakis (2009) elaborate regarding LMS/VLE (Virtual Learning Environment) and state that they are the
primary tools used to implement e-learning. Furthermore, according to El-Bakry and Mastorakis (2009) LMS/VLE are different acronyms for the same concept. LMS/VLE are variations of CMS (Content Management Systems) where the focus is on learning. In summary, e-learning is then a broad term defining the digital consumption of learning content over the World Wide Web using 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 (Koohang, Riley, Smith, & Schreurs, 2009; Means, 2009; Orellana, Hudgins, & Simonson, 2009) Taylor’s (1999) conceptual framework that describes the evolutionary development of distance education 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 (Means, 2009; Zhang, 2005). In addition, Zhang et al. (2006) 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. Therefore, 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 (2008) defines cloud computing as a 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” (Hayes, 2008). Erickson (2009) further narrows the concept of cloud computing to that of cloud-based collaboration. 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 World Wide Web and subsequently primarily web browser based.

**Constructivism and Instructional Design**

Given that e-learning uses LMS/VLE, which are based in the cloud and web browser and contain multimedia content, how do we then maximize the instructional design of a collaborative cloud-based tool? As defined by Willis (2009) “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 (Beldarrain, 2006; Koohang & Harman, 2005; Koohang, et al., 2009; Moore, 1989; Snyder, 2009; Tam, 2000; Zhang, 2005) in the disciplines of e-learning and constructivism emphasize the importance of and emphasize the beneficial aspects of using constructivism to design e-learning artifacts and environments. Additionally, the constructivist learning model is the most commonly adopted in e-learning (Zhang, 2005). 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 (2000) 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 (2000) 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 (2009) concisely summarizes constructivism and e-learning environments by stating that “constructivism supports learner-centered environments that are authentic, collaborative, constructive, and active”.

**Issues with e-learning**

The previous section provides a definition of e-learning and LMS as well as the pedagogical theories that call for collaboration and interaction in the design of e-learning. The following sections present problems found in previous research with e-learning. These problems are defined and grouped thematically.
Collaboration

Much previous research describes and studies the need for users of an e-learning system to collaborate in order to construct knowledge together. Recent research such as that by Liesebach et al. (2011) describes how an e-learning environment should support unrestricted use of collaboration and communication tools. The key issue is therefore the general need for users to seamlessly collaborate synchronously and asynchronously directly in the e-learning environment.

Interaction

A significant, 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 (2006) 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 (2000) emphasizes the importance of social interaction when she states that “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 (1989) defines three types of interaction in learning: learner–instructor, learner–learner, and learner–content. Moore 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 (2005) succinctly summarizes 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. (2006) 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 (2006) 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. The aforementioned research and pedagogical principles also show the importance of interaction between the users and the learning content. E-learning environments therefore need tools that allow users to interact with the content in a simple and intuitive manner.

Individualization

Another issue with e-learning is its lack of personalization or individualization. This refers to the ability of the user to change the e-learning environment (adaptability) and the environment to change automatically given some cue (adaptive) (Santally & Senteni, 2005). Cristea (2003) states that “one of the main problems with e-learning environments is their lack of personalization” and that e-learning environments cannot offer diversity to the student only identical contents. Santally and Senteni (2005) state that individualization and personalization of web-based e-learning is vital. Furthermore, Anderson (2009) summarizes research regarding individualized learning stating that there is a shift from provider focus to learner focus and that mass customization can be achieved through individualized learning systems. Liesebach et al. (2011) reinforce the idea of individualization stating that users should be able to structure the contents of an e-learning environment as needed. Similarly, Kritikou et al. (2008) also summarize the prevalence of personalization in e-learning environments and present a concept of how the system itself can adapt to the preferences of the user.

Updated relevant content

The concept behind this issue deals with the problem of e-learning environments containing static, non-dynamic material. The existing learning material is fixed and seldom changed, neither by the teacher or the student during the lifetime of a particular course. Hage and Aïmeur (2008) present a technology called SHAREK that allows users of an e-learning system to share knowledge and resources related to a specific e-learning content. SHAREK showed positive results among its users. This research supports the concept of reusing user-generated content and information in order to create a more dynamic, e-learning environment.

Performance

The performance theme refers to the idea that the web application that hosts an e-learning content must perform as well as a desktop application. Because e-learning environments are web-based, performance is an issue. Performance issues for web applications vary in form and scope. However, Google is making a serious attempt to address web performance issues from Internet protocols to web page rendering (GoogleCode, 2011). The two primary bottlenecks are transmission of information and rendering of learning objects in the browser. Both contribute to poor performance and GUI unresponsiveness. Inline with aforementioned research, collaborative e-
learning should 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 (Nah, 2004) 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.

Device ubiquity
This theme focuses on the issues regarding delivery of e-learning to a variety of devices. E-learning today is focused on delivery via PC. Probable devices for future consumption are most likely smartphones, tablets, etc. in addition to PCs. Kemp et al. (2008) define the need for an invisible delivery of e-learning content that is not dependent on an LMS or PC environment. Furthermore, the trend in e-learning is moving towards m-learning which can be defined as the extension of e-learning to mobile devices that truly makes learning available anywhere and anytime (Lam, Yau, & Cheung, 2010). Furthermore, Lam et al. (2010) point out that mobile technologies are now mature enough to support e-learning and can even enhance interaction among teachers and learners.

Poor completion rates
This theme deals with the common knowledge that e-learning courses have a much higher drop out rate than traditional courses. The reasons behind this have been researched in a variety of ways over the past 10 years and the results vary and are non-conclusive. However, a recent study by Levy (2007) finds that a key indicator for dropout rates in e-learning courses is students’ satisfaction with the e-learning course. Furthermore, the study shows that academic subject did not affect the results and students completing an e-learning course had greater satisfaction than those not completing the course.

HTML5 and related technologies
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. 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 (Wikipedia, 2011a). 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 (WHATWG, 2010). 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 list provides insights into how specific attributes of HTML5 and the new JavaScript APIs can provide the tools needed to create a collaborative e-learning environment (Jobe, 2011).

Interaction and Individualization
• **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 (W3C, 2010b).
• **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 (W3C, 2010b).
• **JavaScript APIs and jQuery** – jQuery is an open source, cross-browser JavaScript library that is used to simplify scripting of web pages (Wikipedia, 2011b).
• **CSS3** – A new improved version of CSS (Cascading Style Sheets) that offers greater control and flexibility for creating modern designs by using things such as rounded corners, opacity, shadowing, animations, multi-column layout, web fonts, multiple backgrounds, media queries, etc. (W3C, 2001).

Collaboration and 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 (W3C, 2009a).

- **Cross Document Messaging** – HTML5 allows web browser frames, tabs and windows from different origins to communicate securely and directly with one another (Lubbers, Albers, Smith, & Salim, 2010).
- **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 (W3C, 2010a).
- **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.

**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 (W3C, 2009b).

**Semantic Web**

The semantic web refers to the concept of creating a web of data and not of documents. The intention is to create ontologies of information so that web pages contain metadata about the content and provide meaning. HTML5 supports both Microdata and RDFa (W3C, 2011)

- **Microdata** – This feature in HTML5 allows for semantically defined web pages. In short, the Microdata standard provides five new attributes: itemid, itemprop, itemref, itemscope, and itemtype. These item value pairs and the attributes can be used to provide meaning for various parts of a webpage. In other words, web pages can become machine readable (W3C, 2010c).
- **RDFa** – RDFa is a W3C recommendation for embedding metadata into web documents. RDFa is essentially a set of attributes that uses XML to define metadata (Wikipedia, 2011c).

**Why HTML5 is the future of e-learning**

HTML5 in combination with CSS3 and jQuery provide the necessary tools to move e-learning environments from being static web-based copies of traditional learning materials to collaborative web applications that provide multimedia content that is interactive, responsive and dynamic. These tools can be used to resolve or alleviate the aforementioned problems in the following ways.

**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 environment can be a truly collaborative environment. Web Sockets and SSE can provide a full-duplex connection between users so that the exchange of text, images, audio, video, etc. can take place quickly and efficiently. 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 e-learning environment and even make possible collaboration in the physical world by being able to easily show the location of each user. Furthermore, users can chat in real-time or post messages/statuses that can be read asynchronously with little or no latency. The meaning of collaboration in this context also incorporates geolocation and presence, which is the concept of showing when users are online and where they are physically (upon approval).

**Interaction**

As previously described, the central principles of constructivism, deal with the concepts of constructing knowledge through interaction with the content and other users. Interaction in this context focuses on the constructivist pedagogical ideas of constructing knowledge by removing, adding or modifying existing learning
objects in some way. The specific tools for this will be the JavaScript APIs and JQuery as well as the canvas tag in HTML5. The porting of HyperCaster (http://sourceforge.net/projects/hypercaster/), which is an interactive overlay for video, to HTML5 can even be used for video specifically in this context.

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, images, etc. 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. They can drag and drop documents, images, audio, video, etc. directly into the collaborative environment. 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.

Individualization
By allowing the users as well as the system to customize and personalize the e-learning environment, this issue can be addressed. The contentEditable attribute in HTML5 makes it possible for the designer to allow the user to directly change the structure and content of an e-learning environment. Furthermore, utilizing an instructional design in the e-learning environment that permits the user to adjust the learning path through the content also contributes to individualization. This concept of individualization is even affected by the following concept of updated relevant content. When users and the system generate original content, they then can individually decide what is to be shown and used. This capability further enhances the idea of individualization of the e-learning environment.

Updated relevant content
Allowing the users and the actual learning environment to generate new content can alleviate this problem. Content generation from users is manual and content generation from the learning environment will be automatic. In this scenario the semantic capabilities of HTML5 can be utilized to make possible automatic content generation by the system. Anderson (2009) even describes the use of “autonomous agents to support and facilitate learning” that supports this concept. This idea envisions a semantic web where independent agents read the semantic web and gather relevant data only. By utilizing the semantic capabilities of HTML5 when designing an e-learning environment, the content then becomes dynamic and not static. Dynamic content provides a motive to return to the environment to discover what the system and/or other users have added. The previously mentioned research by Hage and Aïmeur (2008) directly explore the ideas of resource reuse with positive results and their tool SHAREK could possibly be adapted with HTML5.

Performance
The performance issues of web applications can be reduced by improving network data transmission rates as well as improving content rendering times. By using HTML5 web sockets, full-duplex communication between the server and web browser is possible. Rendering is improved through JavaScript optimizations, which are constantly taking place in modern web browsers. Furthermore, the client computer (web browser) renders JavaScript and therefore the performance of a web application becomes more scalable as increasing the number of simultaneous users increases network traffic but server performance is not significantly increased.

The Web Worker attribute in HTML5 addresses the performance issue directly. By designing an e-learning environment with web workers, a web application 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 as well as the content. Web Sockets can even improve network utilization by making chat functions and other forms of communication between the server and client even more responsive due to the ability to send data full-duplex in real-time between the web browser and the client.

Device ubiquity
An e-learning environment needs to seamlessly present content in an optimal manner regardless of the device or screen size, without creating different versions of the environment. Vector graphic support in HTML5 and
the canvas tag along with CSS3 can be used to design the GUI so that content scales appropriately regardless of device or screen size. These tools then provide the ability for an HTML5 designed e-learning environment to be developed one time but then be delivered with little change to a variety of devices, from smartphones to wide-screen televisions. The only software needed is then a compliant HTML5 web browser to make a HTML5 based e-learning environment an m-learning environment.

**Poor completion rates**

The reasons behind this factor vary and one concrete solution is thereby difficult to find. The goal here is to attempt to make the e-learning environment modern and attractive using CSS3 and HTML5 so that the learning experience is improved and that the entire environment is individualizable so that each separate user can adapt the environment as he/she prefers. Hopefully, this can ultimately have some effect on completion rates. Furthermore, WebGL and the possibilities of incorporating 3D environments in e-learning environments can hopefully improve the learning experience as well. Much research has been done using 3-D virtual environments such as Second Life in various learning environments with positive results.

**Concluding Remarks**

Dagger et al. (2007) speculate on the future of e-learning stating that e-learning models that are built on rigid LMS frameworks do not match with the open ideology of the Internet and e-learning as a deliverable product is also non-viable. Dagger et al. (2007) continue by stating that “every contribution to the Web has a learning-related value associated with it, and that tomorrow’s e-learning platforms will deliver knowledge when, where, and how you want it.” Therefore, this paper proposes a new e-learning environment built using the outlined aspects of HTML5 and related technologies, which is inline with Dagger et al. (2007) general ideas. This new prototype for an e-learning environment can either be used as a standalone environment or incorporated into existing LMS, e.g. a module in Moodle. A qualified pedagogue creates the initial content and design of the e-learning environment. Then the users and system through collaboration, interaction, and the use of semantic tools can build and grow upon the contents and structure of the e-learning environment.

Ideally, everything in the environment is interactive and customizable by the users according to the restrictions set by the responsible pedagogue. All changes or additions to the learning environment whether by a user or the system can be made private or public. Private changes can be stored locally in localStorage in HTML5 and public changes globally in a database. All the changes from the users and the system can be ranked and the responsible pedagogue can set a threshold for showing externally generated content. For example, content having 3 of 5 stars or greater will be shown. By utilizing the new, powerful tools for HTML5 e-learning environment can truly become web applications that are collaborative, interactive, dynamic and individualizable. The next step is to develop and test suitable HTML5 prototypes in a variety of e-learning situations.

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