HIVE (Hypermedia Interactive Virtual Environment) – Utilizing HTML5 and instructional design to improve online learning

Abstract: The aim of this paper is to summarize the challenges faced in online learning and the instructional design of online learning tools brought about by the emergent technologies of HTML5. The argumentation draws on an overview of contemporary research on the design of educational technologies, together with the affordances and technologies of HTML5. Consequently, the contributions of this paper are that the imminent web technologies of HTML5 in combination with instructional design changes in an online learning environment that uses hypermedia and constructivist learning principles can make a dramatic difference in the effectiveness and improve the learning outcomes and experience of online learning tools. HTML5 represents a revolution in how online learning tools can be implemented in the future. Finally, the author proposes that a prototype called a HIVE (Hypermedia Interactive Virtual Environment) be developed to harness the power of HTML5 to deliver interactive, individualized and collaborative content for online learning. A HIVE can either be used stand-alone or integrated with existing LMSs.

Keywords: LMS, Hypermedia, HTML5, Constructivism, Mass Individualization, Online Learning

The state of online learning

The design space for online learning is rife with challenges as always, and there are new, viable solutions on the horizon. Online learning has grown substantially since the advent of the Internet and the World Wide Web. Taylor’s (1999) conceptual framework that describes the evolutionary development of distance education is very applicable in the context of this paper. Taylor’s first generation is the correspondence model that involves printed, analog material. The second generation is called the multimedia model consisting of print, audiotapes, videotapes, etc. The third generation is called the tele-learning model involving video conferencing and broadcast educational TV/Radio. The fourth generation is the flexible learning model that is characterized by the use of the Internet and Web for asynchronous distribution and access of materials. The fifth generation is intelligent flexible learning that is characterized by interaction, Internet-based resources and automated response systems. Taylor’s fifth generation through the use of automated response systems even offers improvements in economics of scale so that online learning environments can manage hundreds or even thousands of learners at a time. Distance education today represents the culmination of the process from the first generation of correspondence systems to the current LMS (Learning Management System) systems that are arguably representative of the fourth and fifth generation of distance education that are predominantly used online. (Unesco, 2002) Taylor mentions the “cottage-industry model” where the same individual that teaches face-to-face even does everything for distance learning (Taylor, 1999). This artisan creates the digital content, organizes it, publishes it, then finally supports, tutors and examines the learners.

Therefore, the primary approach for delivering online learning material today is via an LMS and they have become the standard for online learning management. Using Taylor’s terminology most of these systems are a mix of the 4th and 5th generations. Chandler (1999) found that many course activities are more effectively delivered over the Internet such as lecture notes, ancillary reading, class discussion, interactive exercises, etc. However, despite tertiary education moving rapidly into online learning, problems still persist regarding quality, access and sustainability (Evans, 2008). There are a variety of LMS choices on the market today ranging from proprietary solutions such as BlackBoard and open-source solutions such as Moodle (Yueh & Hsu, 2008). In addition, many institutions choose to create their own solutions, e.g. (Svensson, 2002; Wainwright, Osterman et al., 2007). Regardless of the type of LMS in use, they typically share similar capabilities and traits, such as learning content publication, learner administration, communication tools such as forums and email, assessment tools, etc. A key characteristic for this paper that LMSs share is that they typically manage both learning and the administration of a course and the learners. LMSs are not strictly learning tools; they are both containers for learning content and activities, but also devices used by learning institutions to administer learners and their studies. LMSs deal with learning, but focus on old paradigms of how learning institutions have always operated. They are in essence CMSs (Content Management Systems) with a learning focus. Other common tools for online learning are wikis and forums. They can be part of LMSs or used stand-alone. Wikis manage knowledge via social consensus. Experts and laymen accumulate and summarize knowledge that can be viewed by anyone. However, entirely open learning
environments like wikis, which lack structure and goals, are not optimal for learning a specific subject. Forums are useful for answering common questions, but there is often a lack of structure, goals and multimedia.

The drawbacks of traditional LMSs are not only the divided focus on learning and administration. Many LMSs lack an explicit pedagogical design. Vrasidas (2004) points out that LMSs are often ineffective and are used to “put content online” without applying solid pedagogical principles. Vrasidas even refers to other research that argues that commercial LMSs do not enable the use of constructivist learning methods and that most LMSs duplicate typical face-to-face instruction. Vrasidas even points out that there is a strong movement towards constructivist learning. He lists five aspects of constructivism: i) learners engage in active learning, ii) knowledge is represented in multiple ways, iii) learners participate in authentic activities with real-world connections, iv) work is evaluated with authentic assessment methods, v) learners collaborate with peers solving real world problems, and vi) learners have access to distributed tools for meaningful learning. Marra (2002) can be summarized by succinctly implying that the aspiration of an “ideal online learning environment” is one that provides an architecture upon which learners can fully develop their intellectual potential. Further support for using constructivism as the primary pedagogical design motive in a learning environment is provided by Phillips and Soltis (2004) who summarizes in his book a variety of learning perspectives. Classical teaching methods such as behaviorism and didactics to Piaget’s constructivism and Vygotsky’s situated learning are presented and summarized. Online learning, just as learning face-to-face, mixes these various perspectives on learning, despite the fact that researchers claim that constructivism and situated, collaborative learning represents a revolutionary change and a paradigm shift in teaching (Evans, 2008).

The use of multimedia is also an important aspect to be considered. Bates and Poole (2003) classify media and technology and their impact on teaching and learning into three main categories: broadcast, i.e. simplex vs. interactive i.e. duplex, synchronous vs. asynchronous, and transient vs. permanent. According to Evans (2008) the Internet and Web are potentially the most potent educational technologies because it is the only technology that integrates these 3 categories. Therefore non-linear, interactive multimedia or hypermedia can be an important aspect of an online learning environment. Borsook and Higginbotham-Wheat (1992) claim that hypermedia gives the learner more control over the learning environment, that it enhances collaborative learning, and that from a psychological standpoint, hypermedia more closely resembles how the human brain functions.

Dichev and Dicheva (2005) found that the organization of online material should not mirror that of a textbook and that a richer access structure is needed because the need and intent of the student cannot be foreseen. Distance learning tends to duplicate the classical classroom instructional model (Taylor, 1999). What are some current areas and aspects of online learning and LMSs, where improvements can be made? The following aspects of online learning are areas that a learning environment based on constructivist learning should focus: collaboration and social interaction, personalization and individualization, interactivity with content, and subject structure and guidance. Furthermore, a modern learning environment should even attempt to provide technical improvements such as scalability to accommodate large numbers of learners, performance improvements to increase online responsiveness, the ability to work offline, and a graphical user interface that allows device ubiquity and encourages interaction.

Given the apparent deficiencies in LMSs the need for better online learning tools is as great as ever. Distance education may play a more important role in the future to solve the problem of shortages of teachers as well as educational administrators and professionals in both developed and developing countries (Unesco, 2002). There are more distance education courses offered at the tertiary level than at any other level, and teaching remains organized as a craft not a system (Unesco, 2002). What is needed is a tool that allows teachers to continue to express their craft online. Consequently, the argument of this paper is that a new “revolutionary” learning environment is needed that addresses the shortcomings of LMS systems and current pedagogical designs, and meshes them into a better vessel for learning. The missing ingredient in such a solution is the addition of a modern, standardized web environment that has the tools necessary to create such a learning atmosphere. In the following section the new innovations of such a web technology are outlined.

New Solution, New Tools

As previously stated online learning solutions are delivered with a variety of LMSs and an integral part of a learning environment is multimedia. Multimedia is primarily delivered with proprietary tools such as Adobe’s Flash
and Microsoft’s Silverlight. These media platforms are the two primary players for delivering interactive multimedia via online learning tools. However, there are non-proprietary, open standards under development that can provide equivalent, interactive multimedia natively in the web browser.

The Next Generation of Web Tools

HTML5 is the impending official standard from W3C (www.w3.org) which is the official, non-profit organization founded and led by the inventor of the World Wide Web Sir Tim Berners-Lee. The W3C establishes the various web standards by vote and discussion of the member organizations that include the majority of leading IT organizations. HTML5 is currently a W3C Editor’s Draft. This means that HTML5 is currently not a W3C recommendation and thereby not an official web standard yet, however, this standard makes revolutionary changes in how HTML can be used 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, 2010). 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). JavaScript APIs (Application Programming Interfaces) refer to the new JavaScript APIs that used in combination with HTML5 offer web developers new native tools to create interactive and responsive online environments. HTML5 and the new JavaScript APIs quite simply represent a technical revolution in web development. Here is a comprehensive list by topic of the new technologies that are likely to have a profound impact on services for online learning.

Multimedia

Audio and Video tags - HTML5 provides native support for audio and video. A majority of the multimedia content currently delivered via online learning is either audio or video. These new HTML5 tags allow for audio and video to be directly supported by the web browser without a need for any form of third party plug-in (W3C, 2010).

Device tag – HTML5 is even developing a tag termed Device that will allow web applications to directly access USB devices such as web cameras. This tag would make it possible for natively implementing video conferencing and streaming in the web browser without third-party programs (W3C, 2010).

Awareness

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, 2010).

GUI improvements

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, 2010).

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, 2010).

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.

SVG – inline support for SVG (Scalable Vector Graphics)

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).

File reading and Drag & Drop – Using the new File API in HTML5, web applications can request users to open local files and the web application can then read and access the contents. Furthermore, web applications will support the ability for the user to drag & drop files directly into the web application for use (W3C, 2009).

Semantic Web

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, 2010).
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, 2010).

Communication

Web Sockets – 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 push of information from the server to the client web browser (W3C, 2009).

Offline Web Applications – Offline Web Applications is a JavaScript API that used in combination with HTML5 provides the ability for a web application to determine if there is a network connection to the Internet, i.e. if the web application is online or offline. In addition, a manifest file can be supplied to the HTML5 document that defines which files must be downloaded so that work can be done offline. Standard compliant client and server upgrade from the HTTP protocol to the Web Socket protocol via the handshake process so that following communication between the two can be made in full-duplex mode (W3C, 2008; Lubbers, Albers et al., 2010).

Cross Document Messaging – HTML5 allows web browser frames, tabs and windows from different origins to communicate securely and directly with one another (Lubbers, Albers et al., 2010).

Data Storage

Web Storage – Web storage is the new HTML5 way to store information on the client. Previously, this was done with cookies. Unfortunately, cookies have size limitations (4kb), vary in the number that can be created depending on browser, and they are transmitted to the server on every request. Web storage increases storage amounts to at least 5Mb and many browsers allow much more. Web storage consists of two parts: localStorage and sessionStorage. localStorage is permanent and persists even when the browser is closed. sessionStorage is transient and is removed when a browser or tab is closed (W3C, 2010).

Instructional design with a focus on individualization and collaboration

Following the ideas of constructivism and situated learning, a modern online learning environment should consist of a combination of these two learning theories so that learners can construct knowledge. Furthermore, hypermedia should have a prominent role in the content and design of a subject matter. Some pedagogical design features that should be available in an online learning environment are:

- Allowing learners to add, edit, comment, and take notes on content.
- Allowing learners to collaborate directly and via content.
- The environment automatically adding relevant, external content based on semantic cues.
- Use of an interactive learning path for constant feedback on learning goals.

Prototype concept – a Hive

LMSs dominate online learning but they manage and administrate. This current learning paradigm needs an injection of new ideas and technology to return the focus to learning outcomes and experiences. Integrating HTML5 technologies with constructivist pedagogical principles can make for a new, powerful online learning tool that strictly focuses on learning by maximizing interactivity and collaboration. HTML5 and accompanying technologies represent the next wave of revolutionary web development tools. Constructivism, as argued previously, is an ideal learning pedagogy for online learning where individualization, interactivity and collaboration are at a premium. A HIVE (Hypermedia Interactive Virtual Environment) is a concept for a prototype that only focuses on learning by using hypermedia in a HTML5 web application and constructivistic pedagogical design principles.

A HIVE prototype will be a learning environment filled with interactive hypermedia. Subject matter will be composed of modules that in turn contain relevant hypermedia, text, learning goals and outcomes, activities, etc. A HIVE will run in the web browser exclusively using HTML5 techniques. Ideally the environment will operate in
full-screen mode without using the browser’s navigation buttons. Imagine a learning environment filled with a mixture of text, images, video, and audio where every learning object is interactive through implementation of a HTML5 canvas. Optimal use and interactivity of hypermedia can thus be achieved by using the canvas tag in combination with a variety of multimedia. The learner can directly interact with hypermedia objects by adding comments, links, and even new resources via context menus and all these additions can be either private for the individual learner only or public for all learners. Furthermore, an interactive dock will be accessible at all times and will contain a “learning path” composed of clickable icons of each page in the HIVE, so that the learners can always access the learning goals and outcomes as well as view where they currently are on the learning path. The HIVE will have a starting and ending point based on the intended learning outcomes but navigation through the material must not be linear. Learners can place bookmarks anywhere in the dock or learning path, for later reference. In addition, other collapsible menus will offer access to personal notes for the current page, access to available external resources and access to collaboration with other learners via direct chat messaging, online status, and presence using HTML5 cross document messaging, Geolocation, or other forms of social media integration. Due to the use of HTML5 the user interface will be responsive by using Web Workers and Web Sockets, be interactive by supporting drag-and-drop of various multimedia and opening of local files, and be usable offline. Below is a rough concept of how a HIVE can appear. Navigation through the subject can be done “view” by “view” with the arrows on the sides or with the learning path at the bottom. Transitions through the material will be dynamic and animated by using CSS3. Moreover, each hypermedia object is interactive and the learning path and windows to the right collapse out of view when not in use. Design aspects such as font style, colors, etc. will be customizable by the user.

Figure 1 - A conceptual, wireframe mockup of how a HIVE can appear.

Concluding Remarks

Currently, a HIVE is a conceptual prototype that intends to utilize new, innovative HTML5 technologies along with constructivistic learning principles that only focuses on learning and not learning administration. HTML5 offers the tools to create an open, standards-compliant, plug-in free learning environment where all aspects of learning can be implemented natively in the web browser. In addition, the combination of HTML5 along with constructivistic concepts of individually and collaboratively constructing knowledge will allow for a HIVE to facilitate mass individualization and social collaboration. Additionally, a HIVE will automatically be a device ubiquitous environment due to the user interface being created with the canvas object and CSS3. All HTML5 elements will scale correctly so that a HIVE can be viewed on anything from a widescreen TV to a smartphone. All the content can even be accessed offline. The only thing needed is a compliant web browser. A HIVE can potentially
be implemented as a stand-alone online learning solution. In such a solution a self-guided/self-directed online course or an informal learning course may be most appropriate. Such a solution would even be a novel environment for teacher education courses. Imagine a HIVE for teacher education shared by numerous institutions. A HIVE would provide an interactive environment where teachers could collaborate, share content and gain access to a multitude of external resources. Furthermore, in this scenario, a HIVE could perpetually exist and constantly grow and change to adapt to teachers needs and quite possibly be used as a resource in the classroom eventually. Additionally, a HIVE solution could be implemented through integration into existing LMSs. Such a solution would offer the individualization, interactivity and collaboration of a HIVE while not sacrificing the administrative capabilities of an LMS.

Theoretically a HIVE, due to the use of HTML5, should even offer performance improvements by using web workers and web sockets. The ultimate goal is that a HIVE will be able to make online learning as interesting, interactive, collaborative, and personalizable as possible so that better learning outcomes will be achieved that can counteract hindrances associated with online learning such as performance issues, poor completion rates, scalability, etc. Overtime a HIVE can grow and prosper due to the learning environment itself automatically searching the web for related hypermedia and due to the learners adding their own hypermedia. In this way the concepts of mass individualization and collaboration merge allowing learners to construct knowledge as suggested in constructivism. A HIVE may even contribute to blurring the gap between face-to-face and online learning so that eventually the learner does not contemplate on the delivery method. The process and result of teaching using online learning may even return to being an enjoyable craft and not just a cumbersome, technical process that distracts instructors from their face-to-face teaching. Though full support for all aspects of HTML5 in all web browsers is not available yet and the choice of video codec for the video tag is in dispute, the majority of new development by the big four web browsers (MS Internet Explorer, Mozilla Firefox, Safari, and Google Chrome) still focuses on HTML5 implementations and performance improvements. The time is ripe to take the next step and revolutionize online learning with HTML5. Therefore, the next ambition in this research is to make a HIVE prototype and field test it in a variety of tertiary and secondary learning environments.

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