Multimedia in E-Learning; How it Benefits, How it Detracts and the Dangers of Cognitive Overload

A Review of the Literature

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Abstract: Multimedia has infused itself into all aspects of education be it online, distance or in the face-to-face classroom. Its presence has become ubiquitous in education and yet has it really benefitted students to the degree it could? This paper utilizes a review of the literature to define the role of multimedia in e-learning then looks at how multimedia fits into basic pedagogy, learning theory and learning styles. An examination of how multimedia optimally could be incorporated into the curriculum is also conducted. Finally a look at cognitive overload is undertaken to determine if there is such as thing as too much of a good thing; can instructors end up confusing students with poorly designed multimedia presentations? There are many tools to use to present multimedia lessons however, this does not mean they all need to be used in a single lesson, and selecting the right multimedia tool, and content is imperative to ensure learning goals are met. Careful selection and attention to instructional design remains the key determinant in successful learning models and the incorporation of multimedia should be used with basic instructional pedagogy in mind.

Introduction

The explosion of multimedia tools in light of the development of a faster and more efficient world wide web has led to the profusion of multimedia tools and learning objects in the educational environment. In fact it could be said that it is this very expansion of multimedia technology that has facilitated distance learning, Massive Open Online Courses (MOOCS) and other online educational activity. While it appears that the addition of multimedia activities to e-learning is beneficial and can assist in making material available to a wider range of learning types, the plethora of material available has turned some courses into veritable mazes of links, options and assignments. While many multimedia tools are extremely helpful, can the design of many presentations can be problematic and actually hinder learning? In their rush to corner the online market, textbook developers now include in addition to their online text, spaces such as MindTap and Pearson Labs where videos, flashcards, sample tests, closer looks, 360 aerial shots and instructor added comments and media all can be incorporated into the learning experience. When well organized many of these tools can be useful, but if instructors are just including them without any thought to instructional design or what student learning outcomes should be, are all these tools really beneficial or is there a point where too much multimedia becomes overwhelming and distracting at best, counter productive at worst? In a traditional classroom or online, one or two multimedia exercises can provide interest, engagement and inspiration, but given the options available now, some instructors can go overboard without thought to what really works and what doesn't. How do and should multimedia tools really fit into e-learning? How can multimedia tools fit into existing and

proven pedagogy? At what point does sending a student out to multiple sites and to perform multiple activities become distracting? At what point does multimedia overload occur and how can instructors best structure their courses to avoid overload while taking maximum advantage of what there is to offer? How are these new tools best managed and integrated into e-learning? These questions examined in light of the literature review.

Definitions

What is e-learning

As globalization of education and the media increases, the need for new methods of imparting information for educational purposes challenge the old traditional classroom model. In the face-to-face traditional classroom, the physical presence of the instructor and the student is required and the instructor maintains control of the course material, discussion and pace of the course. E-learning refers to any type of learning that uses electronic instructional material delivered via the World Wide Web and an Internet connection. (Zhang, 2003 Lau, 2013)) E-learning has been facilitated by the rapid development of information and communication technologies that are used extensively alongside the more interactive Web 2.0 tools. According to Alsadhan et al (2014), interactivity is a key component in the e-learning interface. The use of digital tools allows the increase of such interactivity and a more student centered approach. E-learning implies that control of the pace and delivery of course material is transferred to the student, the instructor becoming a guide on the side. E-learning is often used interchangeably with distance learning, and while indeed that is how it started, it has come to encompass more than just remotely accessed educational content. E-learning can also occur in a face-to-face classroom with the use of digital collaborative tools allowing greater interaction between the student and the learning material.

What is Multimedia

Webster's dictionary defines multimedia as the combination of more than one medium of expression for communication. This definition of multimedia has been expanded in the last 15 years to include technologies that combine several different electronic communication mediums such as text, graphics and images, video, animation and audio. This electronic media content is most often delivered via the Internet by computer. Multimedia has transformed many traditional media such as paper books, text and other written material into online, instantaneously available interactive forms that can be seen, heard or read, allowing for multiple senses to be engaged in the learning material. The integration of multimedia technology has become a core part of e-learning technologies in order to provide means of delivering various forms of content. Lau (2013) describes three primary forms of technologies to deliver multimedia content; communication technologies to impart information, social networks to collaborate and interact and gaming, a relatively new form of educational technology that aims to turn educational content into an entertaining and interactive experience.

Methods

Researching this question began by searching how basic learning theories incorporate multimedia, how learning types are affected by the use of multimedia and if there were any studies that showed negative effects of too much or poorly designed multimedia. Search terms included *multimedia* and *e-learning*, *multimedia overload*, and *multimedia* and *online education*. While searching for these terms in Google Scholar and the University of Arizona Summon database, the term *cognitive overload* appeared which opened up a wide range of articles relating to how information is processed and what can stall learning. Searching with the terms *cognitive overload* and *multimedia* led to several relevant articles including those relating to the positive and potential negative effects of how multimedia is used in the e-learning environment. Focus on peer reviewed journals limited sources to concrete studies and ideas that had been tested, not just blogs and opinions online. While these sources are sometimes useful, they simply did not fit my needs here. Educational e-learning sites such as Educause and online journals such as the International Journal of Emerging Technologies were also searched and utilized. With the

exception of the case study on learning styles (James and Gardner 1995) references were limited to the last 10-12 years as multimedia cognitive overload is a relatively recent phenomenon that has been exacerbated by the recent explosion in multimedia educational content.

Findings

The Evidence to Support Multimedia in the E-classroom

Multimedia in the E-Learning Environment

As learning moves from the classroom to the online digital environment, multimedia becomes an important component of the electronically delivered classroom. According to Bleed (2005) use of such technologies builds higher concept abilities and a visual literacy that he calls the language of multimedia. The development of multimedia has in many ways provided the means for the explosion of e-learning spaces in recent years. Multimedia has been enabled by high-speed connectivity to open up campus classrooms to off campus students and to allow increased interactivity between students in any kind of classroom. Multimedia applications have been created so instructors and students can create their own multimedia presentations, no longer relying on prepackaged material provided by others. In addition to self generated multimedia, textbook publishers have jumped into the multimedia creation fray; creating a vast amount of content designed to engage the student and assist the instructor. Interactive study spaces, quizzes, flashcards, videos and 360 degree panoramas all supplement the once static written text and in some cases instructors can even embed their own notes and video links directly into the e-book. Abstract concepts can also be expressed more capably using audiovisual effects, graphics, animation and even 3D navigable worlds. Visualization of a DNA strand can help students understand molecular bonding, educational games can make math skills more entertaining to practice and new adaptive applications can adjust to students level of expertise to eliminate frustration and practice skills at an appropriate level. (Cheng, 2009).

Multimedia has also allowed the number of students present in a given classroom to increase as all students need not be present or accessing the learning objects simultaneously. Students can access learning material at their own convenience, asynchronously although some classes incorporate synchronous meetings as well. According to Bower et al (2015) most students find that this multi access learning as superior (57%) or equal (43%) in quality to the traditional face-to-face classroom. Such blended classrooms provide the best of both worlds; the face-to-face camaraderie of a traditional classroom with the flexibility and multimedia tools of the electronic space. It has also been shown that interactive multimedia content can also help improve student performance by increasing user satisfaction and engagement. (Cheng, 2009)

Multimedia and Learning Theory

Multimedia has a place in almost all currently accepted learning theories including Cognitivism, Constructivism and Connectivism. The basic Cognitive model can incorporate multimedia in the use of online visual flashcards to learn vocabulary, subject terms and other tasks that require a more rote type of memorization. Such flash cards go beyond behaviorist theory as they can contain images, sounds or text to maximize the use of multiple senses to retain the information presented. This allows all of Bruner's 3 modes of representation to be addressed and presented, enhancing learning. Bower et al (2015) found in their case studies that these general pedagogy theories can be used to design multimedia to incrementally scaffold and model new skills, also a key component of Cognitivist theory.

Bower et al (2015) also found that multimedia activities can set the stage for authentic tasks, a critical part of Constructivist theory, and one that intrinsically motivates students and enhances engagement. In Constructivism, meaning is constructed as it fits into the student's existing knowledge, as well as the student's perception of the world around them. Multimedia can provide the tools for the problem solving and the project based lessons this theory is based on. Process, not just product is the focus in Constructivism with the student at the center of the learning activity and the instructor guiding on the side.

Connectivist theory has been called the theory of the digital age and it here perhaps that multimedia applications and tools can best be applied (Siemens, 2005). The melding of diverse opinions, connecting information and maintaining these connections to nurture learning are critical aspects of this theory that can best be described as a process of continuous learning. The making of connections between fields, ideas and concepts are a critical skill set that can be fostered by the diverse material being created digitally today, and learning to sift though what is important and what is ancillary is a critical skill for 21st century learners (Bleed, 2005). Multimedia has the ability to foster this approach to knowledge and there is no need to alter existing pedagogy to incorporate such digital tools into the curriculum.

Multimedia and Learning Styles

Multimedia has been explained as being useful to reach a variety of learning styles. As described by James (1995), learning style can be defined as "the complex manner in which, and conditions under which, learners most efficiently and effectively perceive, process, store and recall what they are attempting to learn". The three types of learning styles can be described as Perceptual (physiological or sensory), Cognitive (information processing and problem solving), or Affective (emotional, attention grabbing) and although most people learn best via one of these, everyone utilizes all 3 processes in some form or degree. While it is difficult to select a learning instrument based on learning style, multimedia has the ability to appeal to more than one learning style at once.

By definition as a learning object, multimedia tools impart information, yet they can also appeal to multiple senses in their auditory, visual and experiential nature. Multimedia can be used to provide the variety of communication modes preferable to each learning style. Perceptual mode can be one of the easiest to address with additions of visual material to presentations, electronic interactive discussions and question and answer sessions. The addition of audio can also enhance basic perception adding another dimension to the material presented. Cognitive enhancements can include active participation activities, a map or flow chart containing the primary components of the course, clear objectives, and the provision of alternate paths to learning goals that can be selected by the student. On the affective front, multimedia and technology can allow students to feel less isolated in distance learning, provide peer support, provide more informal testing opportunities and provide images and examples from a variety of cultural perspectives. Multimedia applications also appeal to student attention, as they are often more stimulating than plain textual presentations and can enhance student engagement in all types of learners. (Lau, 2013) It should be noted that not all research supports the existence of learning styles, but multimedia has the ability to appeal to individual learners on multiple perception levels making it an invaluable tool in the classroom.

Failure of Multimedia in the E-learning Context

While different types of multimedia can be created, there are pedagogical reasons why multimedia-learning approaches fail. Instructors need to assure that multimedia tools as easy to use, relatively self-explanatory and that clear learning goals are assigned to each activity so that students know what they are supposed to be getting out of the lesson. Without these parameters it is easy for students to get lost in the technology or frustrated that they do not know what they are supposed to be learning. According to Alsadhan et al (2014) the reasons for multimedia failures include poor planning, insufficient support to teach learners new technologies and difficulty of access. Bower et al (2015) describe an interactive Chinese Island designed to allow language learners to interact with automated characters in a virtual world environment. While the idea was sound, some students experienced technical difficulties including being unexpectedly logged out, loss of audio, and navigations difficulty. Alsadhan's reasons for failure of multimedia approaches can be clearly seen here. Instructors should take note that the mere use of technology to deliver content does not imply that instruction is high quality and that good instructional design is key to success. (James, 1995) Other reasons multimedia instruction can fail have to do with cognitive overload and will be discussed in the next section.

Multimedia and Cognitive Overload

What is Cognitive Overload?

Cognitive overload is a concept associated with cognitive load theory that studies how much information the human cognitive architecture can reasonably manage, particularly in regards to working and long-term memory. (Wong 2012) This theory describes learning as the process of borrowing schemas though the dissemination of another (the instructor's) long-term memory, by consuming content they have created. These schemas are then constructively reorganized into the learner's own long-term memory. Active learning consists of selecting, organizing and integrating information into schema already held by the learner. This reconstruction of information is not exact and random changes can occur causing the learner to test new associations before committing the information to long term storage. If the learner has incomplete prior knowledge with which to integrate the new information presented, problem solving generates new connections and tests their effectiveness ultimately generating new knowledge. It is working memory that must deal with these interactions. When prior knowledge is available, working memory functions smoothly. When prior knowledge is absent, working memory becomes limited as incoming data must be held and made sense of before becoming integrated as new schema. According to Wong (2012) instructional design that does not aim to alter long-term memory and take into account working memory limitations is likely to be ineffective. Cognitive load theory has thus been used to develop many instructional design principles but not all instructors are familiar with these ideas and simply present too many elements in a multimedia lesson for some students to process.

How can Cognitive Overload Occur in E-learning?

Cognitive overload can occur in e-learning when too many multimedia elements are presented sequentially in an attempt to teach a concept. Multimedia technology allows the presentation of animation, audio and text that rapidly disappears (Wong 2012). This type of information is known as transient information. This transient information must be held in working memory in order to integrate it into the next round of data presented, eventually being transferred into long-term memory. Overload can occur when too many transient ideas are offered sequentially that must be held in working memory. While static graphics or text allow a user to go back and refer to what was presented, transient spoken or animated information may be more difficult to revisit and thus create an overload the student is unable to process effectively.

Richard Mayer (2001) studied the use of multimedia and cognitive load extensively, in his article on cognitive constraints in multimedia learning. Mayer and his team found that multimedia can be highly effective in enhancing student's understanding but that often the material was presented too quickly to process effectively. When animation and video was presented rapidly the learner did not have enough time to process it effectively. Also when too much information was presented at once in multiple redundant forms, overload occurred as students had to divide their attention between auditory and visual input and could not process the media effectively unless again, it was considerably slowed down. Both of these processes are what Mayer calls essential processing and overload occurs when the learner is asked to make sense of material too quickly or in too many formats at once. Items such as background music in a video clip also place an incidental processing load on the learner even though it is not integral to the information presented, and can also interfere with retention and lead to overload as well. Mayer also found that presenting an interesting, yet ultimately not particularly relevant video or activity to capture emotional attention prior to a video containing real information overloaded students to the point of confused distraction as it was not clear what information was important and what was not. Finally, what Mayer calls representational holding functions much the same as Wong's transient information processing and cognitive overload can occur when items must be held in working memory in order to process them yet appear and disappear without means of later reference. These results show that instructors must be careful in selecting what multimedia presentations to include, how they are designed, and to make sure learning objectives are met within these presentations in an exciting manner but with little distraction.

How to reduce Cognitive overload in the multimedia rich E-learning Environment

In Mayer's (2015) solutions to reduce cognitive overload in e-learning, he relates how instructional designers can become more sensitive to cognitive load and design learning structures that incorporate multimedia and avoid negative consequences. His first solution is to present text as narration along with visual material and not as text on the screen. This allows processing to be offloaded from the

visual channel to the verbal channel. As visual and auditory material are processed on different channels, this allows input to be synchronized simultaneously and one need not be held in working memory while the other is processed. Another solution is to slow down and segment information in order to present it in more manageable and more easily processed bites. Mayer's segmenting solution is similar to Wong's reduction of transient information by presenting this type of multimedia in shorter chunks that once again are more easily held in working memory. Once one chunk is processed the student can move on to the nest. Pre-training is also another useful solution to overload as it allows students to gain existing knowledge prior to being presented with more material and allows the material to be layered. (Kim et al, 2013) In this case, students would be presented with background material first, in order to understand a concept before being asked to manipulate or apply a model to it. This is also an effective way to avoid technological overload; teach the students how to use an application or program before asking them to create something using it. In this manner a component model is created and stored as prior knowledge prior to the causal model being overlaid, reducing cognitive load and allowing the integration of new and existing knowledge to occur more readily. Weeding is also another suggestion to ease cognitive load and involves the elimination of multimedia that is not strictly intrinsic to specified learning goals. Throwing a presentation in just because it is impressive or interesting or dramatic if it does not relate to learning outcomes is confusing and distracting and these materials should not be included in good instructional design.

Conclusion

How multimedia can best be incorporated into instructional design

Incorporating multimedia into instructional design must be done carefully in order to optimize the e-learning environment and avoid cognitive overload associated with poorly designed multimedia content. The incorporation of multimedia technology alone into the curriculum is not enough, and no amount of technology can compensate for poor instructional design. Good instructional design must take into account how people learn, the amount of material learners can process at once and how to sift through information to get at the real goal of the instructional activity. Substituting technology for pedagogy is not an effective teaching strategy. Instructional designers should arrange a set of tasks and select multimedia that is designed to support the learning process and avoid bombarding working memory with transient information it cannot process at once. Good instructional design intended for electronic delivery must also take into account the advantages and strengths of a particular tool and compensate for any weaknesses. (James, 1995). Many tools are new and exciting but need to be carefully evaluated as to what they are best used to present. Instructors should be wary of throwing every multimedia application they have into a course just because it is available, and evaluation of resources is crucial to achieving learning goals. It is also important that the interactive online learning spaces be kept organized, simple and easy to navigate. (Alsadhan 2014).

In addition, instructors need to make sure students are up to speed with multimedia platforms and that the lesson does not get lost in the technology, which should for the most part be invisible. According to Bleed (2005) students need to be taught visual literacy in order to learn how to use multimedia more effectively as this type of content is better able to provide an experiential, authentic understanding and not just a simple verbal description of an idea, place or theme. Bleed also recommends that such visual literacy should be added to instructional design so that instructors are better able to provide the most relevant and meaningful multimedia available and not just create multimedia for multimedia's sake.

The creation of multimedia content, once only the in the domain of the instructor, is slowly being transformed into something students can complete as part of the learning and assessment process. Collaborative editing technologies such as wikis and blogs have allowed student created content to become more common. Lau (2013) has found students to be more engaged and learn deeper when they take on the role of content author. Once again, prior training needs to be completed before students undertake such projects so the tech does not overwhelm the content. According to Dick and Carey the old manner of teaching where "text was poured down a students throat" has been replaced by the view that learning in a systematic process in which every component (ie teacher, students, materials and learning environment) is crucial to effective learning". (James 1995) Multimedia has the ability to influence each one of these components, but care must be used to select the best tool for the job and take learning goals, basic pedagogy and cognitive overload into account.

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