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Review

Use of Web 2.0 technologies in K-12 and higher education: The search for evidence-based practice

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ABSTRACT

Evidence-based practice in education entails making pedagogical decisions that are informed by relevant empirical research evidence. The main purpose of this paper is to discuss evidence-based pedagogical approaches related to the use of Web 2.0 technologies in both K-12 and higher education settings. The use of such evidence-based practice would be useful to educators interested in fostering student learning through Web 2.0 tools. A comprehensive literature search across the Academic Search Premier, Education Research Complete, ERIC, and PsycINFO databases was conducted. Empirical studies were included for review if they specifically examined the impact of Web 2.0 technologies on student learning. Articles that merely described anecdotal studies such as student perception or feeling toward learning using Web 2.0, or studies that relied on student self-report data such as student questionnaire survey and interview were excluded. Overall, the results of our review suggested that actual evidence regarding the impact of Web 2.0 technologies on student learning is as yet fairly weak. Nevertheless, the use of Web 2.0 technologies appears to have a general positive impact on student learning. None of the studies reported a detrimental or inferior effect on learning. The positive effects are not necessarily attributed to the technologies *per se* but to how the technologies are used, and how one conceptualizes learning. It may be tentatively concluded that a dialogic, constructionist, or co-constructive pedagogy supported by activities such as Socratic questioning, peer review and self-reflection appeared to increase student achievement in blog-, wiki-, and 3-D immersive virtual world environments, while a transmissive pedagogy supported by review activities appeared to enhance student learning using podcast.

Contents

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1. Introduction

Throughout history, educators have always been interested by the question of how technology can be used to transform education and enhance student learning (Hew & Brush, 2007). One of the most recent technologies that have captured the attention of many educators around the world is Web 2.0, a term coined by O'Reilly in 2004 to explain the concept of grouping a set of design and functional characteristics for web pages (O'Reilly, 2005).

Web 2.0, which is also known as the read-write web (Gillmor, 2004), allows two-way communication between the site and users. In its most basic form, Web 2.0 refers to a concept which allows individuals to collaborate with one another and contribute to the authorship of content, customize web sites for their use, and instantaneously publish their thoughts (Alexander, 2006; Heafner & Friedman, 2008). With Web 2.0, individuals can now contribute to the Internet with little technical know-how (e.g., using a Web editor or writing HTML code). Individuals can now become contributors to web sites instead of being mere readers reading the contributions made by others (Heafner & Friedman, 2008). As a result, the content of Web 2.0 sites is constantly changing because content can be updated by multiple authors. It is therefore not surprising that Web 2.0 technologies are hugely popular around the world (Churchill, 2011).

Many claims and suggestions have been made about the educational potential or benefits of these technologies. However, it is important to note that such claims or suggestions are often made *not* based on research evidence, but on mere conjectures. Consequently, such claims or suggestions may not be reliable information or advice for educators to follow. There is therefore an important need to search for evidence-based practice concerning how the use of Web 2.0 technologies might improve student learning.

Following the field of medical science, evidence-based practice in education involves making pedagogical decisions that are informed by relevant empirical research evidence. The main objective of this paper is to review the current literature on the use of Web 2.0 technologies in K-12 school (i.e., both primary and secondary schools) as well as higher education settings (e.g., colleges and universities) in order to discuss possible evidence-based practice (if any) that could provide educators and researchers with informed direction for using the technologies to achieve specific learning goals.

The rest of the paper is organized as follows. We first propose a possible framework to classify the various Web 2.0 technologies. This is followed by a brief description of some Web 2.0 technologies. We then describe our data sources and method of analyses and the resulting findings. In the discussion we focus on several directions for future research related to the use of Web 2.0 technologies in education settings.

2. A framework to classify Web 2.0 technologies

There is currently a large range of Web 2.0 technologies available for educators to use with their students. Adapting the works of Churchill (2011) and Bower, Hedberg, and Kuswara (2010), we propose one possible framework of making sense of this ever-expanding number of technologies – which is to classify them according to their main functionality, and the primary degree of synchronicity they enable (e.g., asynchronous, synchronous). Synchronous tools allow instant access to feedback and comment, while asynchronous technologies provide students more time for reflective thinking (Bower et al., 2010). A summary of some Web 2.0 technologies is presented in Table 1.

According to Table 1, Web 2.0 technologies may be classified based on what they are typically used for (i.e., their main functionality): online reflection, social spaces, online collaboration, social bookmarking, and repository. This list of functionality should not be seen as definitive and exhaustive but merely a way to group the current purposes of the major Web 2.0 technologies.

2.1. Brief description of Web 2.0 technologies

An example of a Web 2.0 tool for online reflection is the weblog or blog (in short). With blogging tools such as Blogger (http://www.blogger.com) and Edublogs (http://edublogs.org), students can easily publish their experiences thoughts online

Table 1
Examples of some Web 2.0 technologies.

Functionality	Technology	Example	Synchronicity
Online reflection	Weblog	Blogger, Edublogs	Asynchronous
Online collaboration	Wiki	PB wiki, Wetpaint	Asynchronous
	Audio discussion board	Wimba voice, Voicethread	Asynchronous
Social spaces	Social network	Facebook, Twitter	Synchronous, Asynchronous
Repository	Video sharing	YouTube	Asynchronous
	Podcast	Houndbite, Chirbit	Asynchronous
Social bookmarking	Social bookmarking	Delicious, Diigo, Simpy	Asynchronous
3-D immersive virtual worlds	Game virtual worlds, social virtual worlds	World of Warcraft, Second Life, Active Worlds	Synchronous

(Bower et al., 2010). Blogs typically share the following features: individual ownership, hyperlinked post structure, post updates displayed in reverse chronological order, and archival of posts (Sim & Hew, 2010). Since blog posts are sequenced chronologically in much the same way as a diary, a blog is often used for reflective thinking (Bower et al., 2010). Blogs can also allow students to view the progress of their thinking (e.g., how their thinking has changed over time) (Ellison & Wu, 2008).

Web 2.0 technologies have also been used by individuals for online collaboration. Perhaps one of the most successful and best known examples of online collaboration is the Wikipedia which has more than 82,000 active contributors working on more than 17 million articles in more than 270 languages (http://en.wikipedia.org/wiki/Wikipedia:About). The use of wikis allows students to exchange ideas, share multiple perspectives, and clarify understandings (Coutinho & Bottentuit Junior, 2007). Other tools, besides wikis, that allow students to collaborate with one another include the audio discussion board such as Wimba voice and Voicethread. Similar to text-based discussion tool, audio discussion board is independent of time and geographical location. However, with audio boards, students could simply speak a question or comment into a microphone and record it as an audio clip on a computer. The clip would then be posted into a threaded organization of other audio clips for other students to hear and give comments.

Social spaces such as Facebook (http://www.facebook.com) and Twitter (http://twitter.com) allow individuals to share personal information or join groups of friends with one another. Individuals typically use Facebook to maintain existing relationships usually involving people with whom they have already formed an offline connection such as an existing friend, or a current or former classmate (Hew, 2011). Twitter is also commonly known as a micro-blog, which is a platform for publishing and sharing short messages (usually 140 characters or less) with other people (Bower et al., 2010; Skiba, 2008). On Twitter, a user can choose which individual (e.g., a professor) to follow, whereby each individual is an information source (Jansen, Zhang, Sobel, & Chowdury, 2009; Skiba, 2008).

Three dimensional (3-D) immersive virtual worlds are online interactive environments which are accessible by many users simultaneously (de Freitas, 2008). 3-D immersive virtual worlds typically share the following features: the illusion of 3D space, avatars that serve as visual representations of users, and discourse tools such as interactive chat for users to communicate with one another (Dickey, 2005). An avatar is the user's on-screen representation, and it enables a user to interact communicate with other avatars in the virtual world (Bailey & Moar, 2001). 3-D immersive virtual worlds should not be considered as synonymous with the term virtual reality because the latter is usually accompanied by stereoscopic viewing devices.

According to Peachey, Gillen, Livingstone, and Smith-Robbins (2010), the two most general categories of 3-D immersive virtual worlds are role play game worlds and social worlds. Role play game worlds have a base story that allows participants' immersion. Participants in role play game worlds typically take on a particular role in order to fulfill certain quests or overcome certain challenges. Examples of game worlds include World of Warcraft, and Everquest. Role play game worlds are among the most widely used examples of 3-D virtual environments (de Freitas, 2008). Social virtual worlds, on the other hand, do not have any game elements (Bell, Smith-Robbins, & Withnail, 2010). For example, there are no base stories, quests, challenges, or rewards (Bell et al., 2010). A social virtual world is a blank slate which allows users to design and create their own world, its objects, and their behaviors (Delwiche, 2006). Objects have properties that allow them to be taken, dropped and so on, which make it possible for students to learn by doing rather than merely learning by listening to the instructor or reading text (Hew & Cheung, 2010). Examples of social virtual worlds include Second Life and Active Worlds.

Social bookmarking tools such as Delicious (http://delicious.com), on the other hand, allow users to save all their favorite websites, share them with other people, and see what other people are bookmarking. Essentially, social bookmarking tools can foster the recall, identification and exchange of factual information on specific topic of interests (Bower et al., 2010).

Finally, repositories such as audio podcast and YouTube (http://www.youtube.com) have made the use of audio recordings and video in the classroom a mainstream event (Bower et al., 2010). An audio podcast uses file-based download instead of streaming (McLoughlin & Lee, 2007). Podcasts can be syndicated and used with the Really Simple Syndication (RSS) which allows their contents to be automatically downloaded to the user (Dixon & Greeson, 2006). YouTube provides a web-based platform for people to easily upload and view. It can serve as a free teaching supplement to inspire and engage students in their learning (Burke, Snyder, & Rager, 2009).

3. Methods

3.1. Sources of data

A search of the literature was performed across the Academic Search Premier, ERIC, Education Research Complete, and Psyc INFO databases. We consider our choices of the four databases were reasonable and sufficient. For example, Academic Search Premier is considered one of the most prominent databases in academic institutions (Blessinger & Olle, 2004). It offers indexing and abstracting for more than 8500 journals. The ERIC database contains more than 1.3 million records and links to more than 323,000 full-text documents. Education Research Complete provides indexing and abstracts that cover all educational specialities for more than 2100 journals, while PsycINFO is one of the largest resources devoted to peer-reviewed literature in behavioral science containing over 3 million records. These databases are frequently used by other researchers in their search for empirical articles (e.g., Luppicini, 2007; Rinke, 2008; Sim & Hew, 2010; Wang, Odell, & Schwille, 2008).

The four databases were used to search for articles using open-ended search period (up till February 29, 2012). The search strategy used is listed in Table 2. The first author read the abstracts of all the studies (n = 4640) initially identified by the four databases. Next, potentially relevant studies were then downloaded, and printed out for a closer examination. Studies were finally selected for the review if they fulfill the following conditions.

First, they must be experiment in design including two groups with random selection, one-group pretest and posttest, or two groups without random selection. Second, the studies must explore the impact of using Web 2.0 technologies on student learning. Articles that merely described anecdotal studies such as student perception or feeling toward learning using Web 2.0, or studies that relied on student self-report data such as student questionnaire survey and interview were excluded. We also excluded studies that reported Web 2.0 for social purposes, or studies that examined the impact of Web 2.0 on users' physical attributes such as visual selective attention, and spatial resolution of attention. Third, the participants of the studies either had to be elementary/primary, secondary (including middle school and high school), or higher education students. At the completion of the search process, 27 articles were eligible for review. We make no claim that the identified publications represent an exhaustive list.

3.2. Data analysis

The basic unit of analysis was each individual research article. Each article was read and its content analyzed according to the following seven parameters in order to describe the key features of the study: (a) Discipline (e.g., language arts, social studies); (b) Web 2.0 technologies (e.g., blog, podcast, wiki); (c) Learning goals or objectives (e.g., improve English narrative writing); (d) Knowledge dimension (please see subsequent paragraph for details); (e) Cognitive process (please see subsequent paragraph for details); (f) Pedagogical approaches (please also see subsequent paragraph for details); and (g) Specific instructional/learning activities (e.g., peer critique, self critique). Any uncertainty regarding the analysis and classification was resolved through negotiation between the two authors.

3.3. Item (d) – knowledge dimension

Anderson and Krathwohl (2001) created a taxonomy of learning, teaching and assessing that could help educators conceptualize learning. It is a revised and updated version of the Bloom's taxonomy. This particular taxonomy includes a knowledge dimension which incorporates the following categories:

(a) Factual knowledge – refers to essential facts, or terminology that people must know in order to be acquainted with a discipline and solve problems in it;

Table 2
Search strategy used for the Academic Search Premier, ERIC, Education Research Complete and PsycINFO databases.

Sequence	Keywords
1	Web 2.0 and education
2	K12 and Web 2.0
3	Blog and education
4	Wiki and education
5	Podcast and education
6	Facebook and education
7	Social bookmark and education
8	YouTube and education
9	Twitter and education
10	Wimba and education
11	Voice thread and education
12	Virtual world and education

(b) Conceptual knowledge – inter-relationships of factual knowledge, including knowledge of classification, principles, and generalizations;
(c) Procedural knowledge – knowledge of procedures, processes, algorithms, or particular methodologies; and
(d) Metacognitive knowledge – knowledge of one's own thinking as well as that of other people.

3.4. Item (e) – cognitive dimension

In addition to the knowledge dimension, the taxonomy (Anderson & Krathwohl, 2001) includes the cognitive process dimension, which consists of the following:

(a) Remember – retrieving relevant information from memory; includes recognizing, identifying, recalling, listing, naming;
(b) Understand – constructing meaning; includes interpreting, paraphrasing, illustrating, instantiating, classifying, summarizing, predicting, comparing;
(c) Apply – using a procedure in a given setting; includes implementing, executing, carrying out;
(d) Analyze – breaking material into its component parts and examining how these parts relate to one another and to an overall structure; includes organizing, deconstructing, finding coherence, integrating;
(e) Evaluate – making judgments based on certain criteria or standards; includes testing, critiquing, checking, monitoring; and
(f) Create – putting things together to form a functional whole; includes planning, designing, producing, constructing, making, generating.

We believe that this particular taxonomy provides a unique two-dimensional framework for evaluating and classifying learning by knowledge type and cognitive process. Such a framework can help researchers and educators to obtain a better understanding about the intended learning, as well as the instructional activities (Su, Osisek, & Starnes, 2004). In addition, the knowledge and cognitive categories as described in this particular taxonomy cut across subject matter lines (Bower et al., 2010). A survey of the education literature revealed that the Anderson and Krathwohl (2001) taxonomy has been used by educators in many different disciplines including computing (Oliver, Dobele, Greber, & Roberts, 2004), medical and nursing school (Su, Osisek, & Starnes, 2004), special and gifted education (Nobel, 2004), music education (Hanna, 2007), and teacher training (Byrd, 2002). Using the Anderson and Krathwohl's (2001) taxonomy therefore allows a more discipline-free way to evaluate the types of knowledge and thinking processes which students are required to engage with.

3.5. Item (f) – pedagogical approaches

Finally, we acknowledge that there are many different ways of classifying pedagogies. However, in this paper, we opt to use Bower et al.'s (2010, pp. 182–183, see Table 3) classification framework because we feel that it enables a more precise way to look at pedagogies based on the degree of negotiation and production that they foster (transmissive, dialogic, constructionist, and co-constructionist). Take for example, the case-based learning (CBL) pedagogy. CBL may be used in the following manner. First, an instructor could use CBL in a didactic teaching fashion to deliver his instruction to students in a lecture. Based on Bower et al.'s framework, this would be classified as the transmissive approach. On the other hand, CBL could also be used by students in a peer interaction or teaching manner. We would refer this as the dialogic approach, after Bower et al. (2010). Classifying pedagogies in this manner according to the degree of negotiation and production they foster seems to provide more useful information compared to merely classifying them by name (e.g., CBL).

(a) Transmissive pedagogies – transmissive-based information delivery approaches, where a stream of information is broadcast to learners;
(b) Dialogic pedagogies – centered on discourse between participants, and often involving exemplars followed by periods of activity and feedback;
(c) Constructionist – where learning occurs by developing a product; and
(d) Co-constructive – groups of learners complete a series of goal-related tasks to produce an artifact.

Table 3
Pedagogies categorized based on their degree of negotiation and production, extracted from Bower et al. (2010, p. 183).

	Non-negotiated	Negotiated
No product	Transmissive	Dialogic
Product	Constructionist	Co-constructive

4. Results and discussion

Twenty-seven articles were eligible for inclusion for this review (see Appendix). Before we describe these articles in greater detail, we first provide some general observations about these studies. First, five types of Web 2.0 technologies were examined and published by researchers to date: blog, wiki, podcast, twitter, and 3-D immersive virtual worlds. The most commonly investigated Web 2.0 technologies is the audio podcast, followed by 3-D immersive virtual worlds. Of the 27 articles, eight dealt with podcast, and seven examined virtual worlds. Twitting received the least attention with only one article examining its effect on first year pre-health professional majors' grade point average scores.

Second, we found Web 2.0 technologies being used in a broad range of disciplines. The majority of the studies dealt with Web 2.0 use in higher education, particularly at the undergraduate level. Only nine studies examined Web 2.0 use at the K-12 level (see Appendix).

Third, longitudinal studies of the impact of Web 2.0 technologies are non-existent. Most studies examined the impact of these technologies over just one semester or less, with some as short as one week. Consequently, there may be readers who dismiss the reported student learning improvements due to the novelty effect whereby participants knowingly react positively to any new intervention regardless of its merit (Clark, 1983; Prince, 2004).

Fourth, one of the problems in determining what works is deciding when an improvement is significant (Prince, 2004). Quantifying the impact of an intervention is often done using effect sizes, which can be considered as the difference in the means of a treatment and control population divided by the pooled standard deviation of the populations (Prince, 2004). Reporting effect size allows a researcher to judge the magnitude of the differences present between groups, thus increasing the capability of the researcher to judge the practical significance of the results derived (Kotrlik & Williams, 2003). Unfortunately, many of the studies reviewed in this paper did not report effect sizes in their findings. Cohen (1977) labeled effect sizes of 0.2, 0.5, and 0.8 as small, medium, and large respectively but did not provide rationale for the labels. Colliver (2000) used this fact as well as the argument by Bloom (1984) to suggest that effect sizes should be at least 0.8 before they could be deemed significant. Using this suggestion, however, would dismiss all the findings reported in the studies reviewed because effect sizes of 0.8 are rare for any intervention and require truly impressive gains (Albanese, 2000). Therefore, we urge the readers caution in interpreting the reported results of the studies reviewed.

In the following section, we briefly describe the key findings of these previous studies according to the type of Web 2.0 technologies employed.

4.1. Impact of using podcast

Eight studies examined the use of podcast and discussed its effects on students who were enrolled in various disciples such as sports science, aviation science, health science, and psychology. The primary pedagogy used in all nine studies was transmissive, with an emphasis on the instructional strategy of listening and reviewing content. The following seven studies reported positive effects: Abt and Barry (2007), Carle, Jaffee, and Miller (2009), McKinney, Dyck, and Luber (2009), Morris (2010), Putman and Kingsley (2009), Siciliano, Jenks, Dana, and Talbert (2011). For example, McKinney et al. (2009) employed a post-test only two groups without random selection design to examine undergraduate introductory psychology students' learning of the topic *perception*. Participants were undergraduate general psychology students in the USA. Students self selected into two different conditions: in-class lecture condition ($n = 32$) and podcast condition ($n = 34$). In the former condition, students listened to a 25 min lecture given in person by a professor using PowerPoint slides. Copies of the slides were given to aid note-taking. In the podcast condition, students received a podcast of the same lecture along with the PowerPoint slides. One week later, students took an exam on the lecture content. Results revealed that students in the podcast condition scored significantly higher than the lecture condition. No effect size was reported. A majority of the students in the podcast condition took notes from the podcast, and listened to it multiple times. The authors concluded that this technique – active engagement and revisions could have contributed to the higher exam scores in the podcast condition.

In contrast, the following two studies reported no effect of podcast use (Baker, Harrison, Thorton, & Yates, 2007; O'Bannon et al., 2011). Baker et al. (2007) examined whether the inclusion of podcasts as a supplementary tool in a blended university course had an effect on student learning of aviation science based on course grade. During the semester, two different 10-min podcasts were provided. Each podcast was an abbreviated lecture of that particular day's 50-min regular class lecture. Students in the previous semester were used as a control group when podcasting was not available. Both the control and podcast groups had access to comparable supplemental study materials (e.g., chapter PowerPoint slides, FAA practice test sessions, and individual review periods with teaching assistants). Quizzes were administered to the control group students. The same quizzes were given to the students in the following semester when podcasting was available. Details of the quizzes such as the types of knowledge or cognitive dimension measured were not described. Results of *t*-tests suggested that the mean score of both quizzes was not affected by the availability of podcasting. However, it is important to note that the sample size was *too small* (only four participants who used podcast, compared with 17 who did not) for much validity to be attributed to the result.

Other researchers (O'Bannon et al., 2011) examined student achievement when podcasts were used in a use of technology in K-12 curriculum course for undergraduate students seeking teacher licensure. Thirty-six students were randomly assigned to a podcast group, while 33 students to a control group. Students in both groups read chapters from the same

textbook, listened to either podcasts or class lectures while taking notes on the PowerPoint slide handouts, participated in hands-on practice, developed project-related materials, and took a 15 multiple-choice chapter quiz. Students in the podcast group listened to 18 instructor created podcasts that merely repeated the text on the PowerPoint slides. Results revealed no significant difference in the achievement of students who experienced podcast instruction versus those who received lecture instruction. However, about one-third of the students had trouble accessing the podcasts. This could have mitigated any positive impact of podcast use.

4.2. Discussion of podcast impact

In this section, we discuss some of the findings, as well as highlight some unanswered issues related to podcasting. First, does the use of podcast really improve student learning? Summing up the studies, the use of podcast does *appear* to have a general positive impact on student achievement. Closer examination reveals that studies that reported positive effects of podcast use tended to share the following three characteristics. First, these studies provided *additional* information or content to students in the podcast group. For example, the gains reported in some studies (e.g., Carle et al., 2009; Morris, 2010; Putman & Kingsley, 2009) could very well be attributed to students spending time on learning more content through supplementary podcasts, and classroom instruction compared to students who had only classroom instruction. The use of supplementary podcasts provided an advantage to students who had access to them, compared to those who had not.

Second, studies that reported positive effects provided the podcast groups with audio recordings of content which were not made available to the control groups. This allowed the podcast groups to listen and review material they missed or did not understand multiple times which enhanced their learning and academic performance. Studies which examined the learning outcomes when the exact contents of materials were provided to both podcast and control groups tended to report either no or trivial effect (e.g., Abt & Barry, 2007; Baker et al., 2007; O'Bannon et al., 2011).

Third, the manner in which the audio podcast contents are delivered to the students may play an important factor too. One of the studies which reported positive effects provided students with just-in-time information about the subject matter via audio podcasts. It appears that this just-in-time information helps students to relate better to the topic they are studying. For example, Siciliano et al. (2011) examined the use of podcast in the learning of landscape architecture and design of English gardens. All students received a course reading packet that contained a brief 2–3 page write-up of each garden, along with PowerPoint slide lectures at the start of the course. Students in the podcast group received audio narratives that covered the same material as in the lecture and reading packet. These audio narratives, however, were produced as a series of garden tours to be used by students to access information about the gardens in real time during actual site visits. Siciliano et al. (2011) reported that students who received the audio podcast narratives produced significantly higher levels of understanding than the control group who did not receive the podcasts. Students in the podcast group appeared to spend more time during the site visits to explore the areas as directed by the audio. The podcasts allowed students to repeatedly listen to the discussion while simultaneously viewing garden elements associated with certain concepts. This suggests that audio podcasts can be an effective tool to engage students in their learning when the podcasts are used to provide just-in-time relevant information.

Therefore, based on these findings, we conclude that the positive effects are not necessarily attributed to the podcasts *per se* but to how the podcasts are used. Still, empirical findings so far suggested that the availability of teacher created podcasts serve as a boon rather than a bane for learning. None of the studies reported a detrimental effect on learning.

Currently, all the studies reported here focused solely on the effects of *instructor* created podcasts (particularly lecture), and supplementary podcasts. The former refers to recordings of lectures or teacher presentations, while the latter refers to recordings of additional information to support student learning. This additional information is not provided during lectures. None of the studies reported the use of student created podcasts. Several scholars have suggested that students should develop their own podcasts that contain either original material or that analyze and deepen the understanding of existing material (Jonassen, Howland, Marra, & Crismond, 2008; Putman & Kingsley, 2009). Jonassen et al. (2008) suggested that the technical aspects as well as the decision-making processes involved in producing a podcast offer students a unique learning opportunity as they grapple with issues related to the purpose and content for the podcast. In addition, the creation of their own podcasts could provide students a greater sense of ownership which could lead to more frequent usage of the podcasts. However, these suggestions are not supported by any empirical findings. Hence, additional research is needed to determine whether the involvement of students in designing and producing their own podcasts may influence their learning performance (Hew, 2009).

4.3. Impact of using wiki

Five studies examined the impact of wiki use on student performance particularly in writing intensive disciplines such as English language and history. The primary pedagogy used in all five studies was dialogic, co-constructive, with an emphasis on the instructional strategy of peer comment and revision. In all these studies, group work was typically employed, with students being asked to write a report or discuss a topic, brainstorm ideas, draft and revise the writing.

Four of the studies reported positive impact with significant difference (Heafner & Friedman, 2008; Pae, 2007; Rick, Guzdial, Carroll, Holloway-Attaway, & Walker, 2002; Wichadee, 2010). One study reported no difference (Neumann & Hood, 2009). An example of a study that reported positive effect is as follows.

Heafner and Friedman (2008) utilized a two group non-randomization design to test high school students' retention of World War II (WWII) facts. Participants were eleventh grade USA history students. One teacher taught two sections of the same class; whereby in one section students developed a wiki as an electronic scrapbook, while in the other section, the same teacher taught the class using a teacher-centered format with an emphasis to pass the end-of-course test. The number of students in the wiki and control groups was not reported. Specifically, students in the wiki group visually presented and explained events that occurred in WWII. Student wikis consisted of eight pages reporting key themes of the war such as: the causes of WWII, USA entry, holocaust, war in Europe, war in the Pacific, and outcomes. Within each page, students posted primary source images, as well as their analysis of each visual and a rationale for its inclusion in the page. Students in the control group, on the other hand, were assigned nightly readings from a textbook that strictly followed a department pacing guide for USA history. The pacing guide dictated what content would be covered on each instructional day, as well as the related textbook readings. Class instruction usually involved teacher centered map work, reading quiz, teacher lecture and question-and-answer sessions. End-of-course test scores revealed that students in the control group on average scored higher than their counterparts in the wiki group. No effect size was reported. Yet, interestingly, in a delayed test about 8 months after the course, students in the wiki group remembered more than students in the control group. The authors concluded that a co-constructive pedagogy that required students to create an e-scrapbook (via wiki) was able to help students retain more content knowledge of WWII over the long term.

On the other hand, Neumann and Hood (2009) reported no significant difference. A wiki was employed as part of a blended learning approach among students in a first year university statistics class. One group of students ($n = 27$, divided into self-selected subgroups of four to six students each) analyzed a data set and communicated the results by jointly writing a practice report through peer revision using a wiki. The other group ($n = 25$) also analyzed the same data set but communicated the results in a practice report written individually. Both groups were taught by three different tutors using the same material. At the end of 6 weeks, students in both groups submitted their own individually written research report for final assessment. This individual assessed report was completed on a different research topic and used an individualized data set. Results of the experiment showed that students who had collaborated using a wiki obtained a *slightly* higher research report mark than their counterparts who did not; however the difference was not significant.

4.4. Discussion of wiki impact

We believe that the studies in this area are still underdeveloped and have several limitations that prevent generalization to broad contexts of wiki use. Three failed to conduct pre-test to determine whether the two groups were equivalent to start off with regard to their prior knowledge or ability of a certain subject or skills (e.g., Heafner & Friedman, 2008; Neumann & Hood, 2009; Rick et al., 2002). One study employed three different tutors to conduct the course (Neumann & Hood, 2009). Even though the same course material was utilized, the use of different tutors could introduce a confounding tutor variable as each tutor might interpret and conduct the material differently. The students in the wiki group in Heafner and Friedman's (2008) study had three licensed social studies teacher present in the computer lab to address content questions raised by the students, but students in the control group had only one teacher. This presented a potential limitation because it created a change in the student–teacher ratio.

Two studies utilized a weak-experiment design that utilized a one-group pretest–posttest design, with no comparison or treatment group (Pae, 2007; Wichadee, 2010). Without a control group, differences found between pretest and posttest scores might not necessarily be attributable to the use of wikis.

4.5. Impact of using blog

A total of six studies examined the impact of using blog. More specifically, three studies investigated the use of blogs in English language learning (Arslan & Sahin-Kizil, 2010; Hsu & Wang, 2011; Wong & Hew, 2010), one examined the impact of blog on student critical thinking in social studies (Salam & Hew, 2010), while the other two studied the use of blogs in dental science and physical education, respectively (El Tantawi, 2008; Papastergiou et al., 2011). The primary pedagogy used in blog studies was dialogic and construction, with an emphasis on the instructional strategy of peer critique and self-reflection.

Of the three studies that examined blog use in language learning, two reported positive gains (Arslan & Sahin-Kizil, 2010; Wong & Hew, 2010). Positive gain was also reported in the use of blog in social studies (Salam & Hew, 2010), and dental science learning (El Tantawi, 2008). An example of a study that reported positive effect is as follows.

Arslan and Shahin-Kizil (2010) employed a pre-posttest two group non-randomization design to examine the effect of a blog-integrated writing instruction on students' writing performance. Fifty students in Turkey (ages ranging from 18 to 21) who were enrolled in a Teaching English as a Foreign Language course participated in the study. The control group ($n = 23$) received in-class process-oriented writing instruction, while the experimental group ($n = 27$) received process-oriented writing instruction supported with blog use. Both groups were taught by the same instructor according to the same curriculum on the same paragraph types, and using the same main materials. The process-oriented writing instruction was as follows: students were initially introduced to the target paragraph essay type, and instructed in the use of relevant vocabulary and language structures. Next, students examined two model paragraphs, and then wrote their own paragraphs of their own topic (first drafts) as homework. Students then received feedback from peers and instructor, and subsequently produced final versions of their paragraphs. Students in the experimental group received the same process-oriented instruction but with

the following differences: through the use of tutor blogs, these students had the opportunity to see more model paragraphs as well as links to other language teaching websites for more language input. Furthermore through blog use, during the drafting process these students received feedback from a larger audience including family members and peers from other universities, in addition to their own peers and course tutor. Results revealed that students in the blog-integrated writing group improved their writing significantly more than those in the control group. No effect size was reported. The authors acknowledged that the gain in performance could be due to students using blog having access to more materials (e.g., more sample paragraphs, language input, feedback) rather than the mere use of blog itself. Nevertheless, the authors argued that these chances were created through blog use.

On the other hand, Hsu and Wang (2011) reported no significance difference. Unlike the other studies on blog use in writing, Hsu and Wang (2011) examined the impact of blog on *reading*. Using a pre-posttest two group non-randomization design Hsu and Wang (2011) studied the effect of blogging on students' reading performance. Participants were undergraduate students in the USA, and two different course instructors. The instruction for both the treatment groups (blogging) ($n = 40$), and the control groups (non-blogging) ($n = 60$) were the same, including the syllabi, textbook, and weekly assignments. There was no significant difference between the two groups in terms of their pre-reading scores. A typical assignment would require students to read an article, identify and organize main ideas, and summarize or interpret the article. The control groups submitted the assignments in hard copies or email attachments, while the treatment groups submitted theirs in personal blog entries with the option of integrating multimedia elements into the entries. The only difference was that the treatment groups were required to read and comment on their peers' blog entries. Data were collected using pre-post reading assessment scores (COMPASS), questionnaire, interview, final course grades, and first semester GPAs. Results showed no significant difference regarding the students' reading scores between the blogging and non-blogging groups. The authors concluded that using blogs did not lend an advantage to participants' reading performance. However, the use of two different instructors in Hsu and Wang's (2011) study might have introduced a confounding tutor variable although the same course material was used.

Papastergiou et al. (2011) also reported no significance difference in their use of blog in the learning of basketball skill. However, the authors cautioned that the students in the blogging group were novices in blogging, which could have led them to pay more attention to coping with the technical exigencies of the assignment instead of actually learning about the basketball skills under study.

4.6. Discussion of blog impact

Unlike wiki studies, students in blog studies tended to work individually (e.g., write an English composition) with feedback and comments from peers or instructors. Students then individually reflected (i.e., self-reflection) on the feedback and produced a final version of their work.

Based on previous research findings, a very *tentative* conclusion may be made – the use of blog appears to have a positive impact on student writing and critical thinking ability (e.g., Arslan & Sahin-Kizil, 2010; Salam & Hew, 2010; Wong & Hew, 2010) rather than reading, or learning a physical skill such as the techniques of shooting a basketball. However, similar to studies of wiki, the studies in the area of blog impact have several limitations that make it difficult to draw reliable evidence-based practice information. First, it was not clearly stated if the two groups in Arslan and Shahin-Kizil's (2010), as well as El Tantawi's (2008) studies were equivalent in terms of their prior ability.

Second, two studies utilized a weak-experiment design that employed a one-group pre-posttest design, with no comparison or treatment group (Salam & Hew, 2010; Wong & Hew, 2010). In the Wong and Hew (2010) study, a writing model guide was used, along with blog, as an outline or mind-mapping guide to help primary school students during the planning process of the writing. The writing model guide consisted of useful linking words, helpful phrases that dealt with action and ending, as well as questions for planning the story. In the Salam and Hew (2010) study, a set of Socratic questions was used (e.g., questions of clarification, questions that probe assumptions, questions about viewpoints, questions that probe reason and evidence), along with blog and podcast to help secondary school students improve their critical thinking. Hence, it is not clear if the gains reported in these two studies could be strictly attributed to the use of blog alone. We could only infer that blogging along with some form of scaffolding (e.g., writing guide, Socratic questions) can help improve students' narrative writing and critical thinking ability.

4.7. Impact of using twitter

Only one study examined the use of twitter on student learning. Using a two group non-random selection design, Junco, Heibergert, and Loken (2011) investigated the impact of twitting on 108 students taking a first year seminar course for pre-health professional majors (students planning to apply to dental, medical, chiropractic, etc. schools). There were 65 students in the twitter group and 53 in the control group. No pre-existing differences in terms of GPAs were found between the two groups. The duration of the study was 14 weeks. Specifically, twitter was used for certain activities, including: (a) to continue class discussions after regular class meeting, (b) to enable shy students to ask questions, (c) to discuss materials pertaining to a book read, (d) to provide academic support (e.g., posting information about the location and hours of the tutoring center), (e) to organize study groups, and (f) to complete two optional and four required assignments. Students in the control group

used the Ning social network. The control group also received the same information and performed the same activities as the twitter group, with the exception of forming study groups. The dependent variable was student overall first semester GPA.

Results revealed that the semester GPAs of the experimental group were significantly higher than those of the control group. However, no effect size was reported. The authors suggested that twitter lend itself more to building conversation between students and faculty. The use of twitter demanded that the faculty members involved in the study regularly monitor and participate in the twitter feed. Students using twitter also interacted with each other a great deal around academic issues. Students on Ning, on the other hand, did not ask as many questions or interact with faculty in the same way as their counterparts did on twitter. More frequent interactions and engagement might have helped increase the GPAs of students using twitter. However, the authors were unable to determine exactly how much of the variance in increased student engagement and improved grades was as a result of twitter and how much was due to a possible orientation of faculty to be more engaged.

4.8. Impact of using virtual worlds

Seven studies investigated the impact of using 3-D immersive virtual worlds on student learning particularly in the science disciplines such as biology, computer graphics, and environmental health. The primary pedagogy used in the studies was dialogic and construction or co-construction.

Five studies reported positive impact on student learning with significant difference (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Holmes, 2007; Ketelhut & Nelson, 2010; Sourin, Sourina, & Prasolova-Førland, 2006; Villalta et al., 2011). Villalta et al. (2011), for example, described the use of a role-play game world to teach 20 sixth graders the concept of food chain. Students took on different avatars with specific abilities such as the "shaman" with the ability to cure diseases and plant seeds, or "hunter" with the ability to hunt. The virtual game world included a number of quests arranged linearly according to the curriculum structure set by the Chilean Ministry of Education. In the first quest, a new alien species entered the ecosystem and began to feed on the predators that were previously at the top of the food chain. Students had to protect the ecosystem by scaring away the new species by working in groups of at least three players. In the second quest, a strange parasite began to affect the animals. The participants had to work together to contain this epidemic. In the third quest, an explosive reproduction of the herbivores occurred. The participants had to work together to prevent the herbivores from completely destroying the ecosystem. As the students advanced in the virtual world, the teacher could pause the game-play and explained a particular concept about the ecological balance being observed in the game. To assess the students' learning, a pre- and post-test that comprised of 20 multiple-choice questions were conducted before and after the virtual game world. The results suggested that students scored significantly higher in the post-test with medium effect size.

On the other hand, two studies reported no difference (Lester & King, 2009; Wrzesien & Raya, 2010). In the Lester and King (2009) study, the same instructor taught a visual communications course to two groups, one in a face-to-face classroom setting, while the other in a completely online format using Blackboard and Second Life software products. Students in the face-to-face classroom attended instructor lectures which consisted of PowerPoint presentations incorporating text, still images and video clips. Students turned in their papers during class. In addition, students had to answer an asynchronous discussion board question each week on Blackboard pertaining to the reading and lecture for that week. For the online Second Life class, the instructor typed out lectures that students could read, rather than speak into a computer-connected microphone. The purpose of typing out lectures was to allow students to review the lecture repeatedly. Similar to the face-to-face class, PowerPoint presentations and video clips were shown in Second Life. Papers were submitted electronically through Blackboard's digital dropbox. Students also answered discussion board questions on Blackboard each week. Both classes of students took three similar examinations that assessed students' comprehension of the material. Lester and King (2009) found that the learning outcomes of the two classes were comparable.

Wrzesien and Raya (2010) examined the learning effectiveness of students that used a 3-D role play immersive game world (E-Junior). The participants were 48 students aged between 10 and 11 years old in Spain. Each student was randomly assigned to one of two groups: the E-Junior group or the face-to-face group. The E-Junior world was structured around narratives that explained scientific concepts about the universe, the earth, and the ecosystem of the Mediterranean Sea. Students worked in groups of four. Each student was assigned a fish avatar such as the Sea Bream, Mediterranean Rainbow Wrasse, Ornate Wrasse, and Painted Comber. With these avatars, students explored and interacted with the virtual aquatic world by collecting elements such as photons, carbon dioxide and oxygen, reflecting on tutor feedback, creating a concept about an issue, and experimenting with the concept during the game. A virtual tutor, represented by a Brown Grouper fish guided the students. The face-to-face class was a lecture presentation. Its learning contents and objectives were similar to those of E-Junior. The teacher explained the scientific concepts, asked students some questions, and invited them to share their opinions about the subject. Students in both classes took the same pre-post knowledge test that comprised questions on the taught science concepts. Results suggested no significant difference in the learning performance between the two groups. This study, however, suffered from several limitations including the deployment of two different tutors who taught the classes, and the different group size of the two classes. The control group participated in the learning in one large group but the experimental group participated as a group of four. This could have influence the learning experience of the students.

4.9. Discussion of 3-D immersive virtual world impact

The majority of the previous studies focused on the use of 3-D immersive role play game worlds rather than social worlds. The game worlds such as Quest Atlantis and River City described in previous research were mainly proprietary platforms rather than commercial ones. To date, we are unaware of work published that highlights the use of commercial role play game worlds for supporting learning. This supports de Freitas' (2008) observation that the use of commercial games such as World of Warcraft are mainly for leisure purposes.

Summing up the studies, we found the use of 3-D immersive virtual worlds appear to have a positive impact on student learning, with five studies reporting positive effect while two indicating no significant difference. The positive impact studies, however, should be view with caution because they have several limitations that prevent generalization. Two studies employed weak-experiment designs that used a one-group pre-posttest design without any control group (Barab et al., 2007; Villalta et al., 2011). Other studies utilized different instructors to teach the courses which might have introduced a confounding tutor variable (Ketelhut & Nelson, 2010), or failed to conduct pretesting or analysis of prior achievement in order to establish group equivalence before doing the achievement comparison (Sourin et al., 2006). In another study, Holmes (2007) conducted a two group design using treatment and control groups. Students were randomly assigned to either groups. However, a closer examination of the study showed that Holmes did not actually investigate a virtual world-based course but rather the roles of software agents as a learning partner. Essentially, the notion of using a software agent as a learning advisor to students could be implemented using other applications such as Microsoft Agent characters (Baylor & Ryu, 2003), instead of virtual worlds (Hew & Cheung, 2010).

Nevertheless, none of the previous studies reported a detrimental effect on learning. Therefore based on these studies, we can be reasonably confident that 3-D immersive virtual world could be a feasible learning environment for course instruction, which produces comparable learning outcomes to students attending real world classes. Specifically, the use of 3-D immersive virtual worlds appears to support a constructionist as well as a co-constructivist learning environment because it enables students to create shapes, sculpt shapes, and showcase their work to others for peer review.

In particular, the use of 3-D immersive virtual worlds seems appropriate for design-based or visual-intensive courses such as computer graphics or object modeling. For example, Sourin et al. (2006) observed that when students worked on their computer graphics coursework in a virtual world (which itself was created using computer graphics tools), then gradually students got immersed in many abstract concepts of computer graphics and could experience real-time rendering and visualization, which would be difficult to achieved if such concepts were only lectured. In other words, the virtual world supported 3-D shape functions and the showcase room supported peer-review feedback. Sourin et al. (2006) suggested that such immersion might explain the better learning of computer graphics concepts that led to a 14% increase over previous course examination scores. Virtual worlds also make it easy for students to manipulate environmental conditions while keeping other variables constant. Such a feature could help students generate and test their scientific hypotheses. Studies that merely utilized the virtual worlds to transmit information such as lecture contents to students (e.g., Lester & King, 2009; Wrzesien & Raya, 2010) tended to report no significant impact of virtual world use.

Finally, although 3-D immersive virtual worlds may afford certain benefits to student learning, we are unsure if it will gain widespread acceptance among educators. In our review of the previous research, as well as based on our own experience with virtual worlds, we found several challenges or issues related to their use. First, one of the main difficulties concerning the use of virtual worlds such as Second Life is cost. Unlike other Web 2.0 technologies such as blogs and wikis, virtual worlds may not be free. Second, some virtual worlds may be too complex for teachers not trained in programming skills to use. Third, not all students may appreciate the use of avatars and the in-world navigations. Some found these elements distracting and interfered with their learning (e.g., Wrzesien & Raya, 2010). Fourth, some users have noted that virtual worlds could take a long time to open or slowed down other programs running at the same time. The use of 3-D immersive virtual worlds may not be optimum on machines with slow graphic cards or Internet connections.

5. Conclusion

Despite the widespread use of Web 2.0 technologies by students and its increased use by tutors, little is known concerning the impact of these technologies on student learning. This paper undertakes a literature review to determine if using Web 2.0 technologies for instructional purposes can impact K12 and higher education student learning performance. A total of 27 experimental studies were examined.

So does using Web 2.0 technologies enhance K12 and higher education student learning? Based on our review, we offer the following conclusions. First, our review overall suggests that the actual evidence regarding the efficacy of Web 2.0 technologies is as yet fairly weak. At this moment, we cannot yet, through these studies, determine actual *causal effects* of Web 2.0 technologies on gains in student achievement due to various methodological concerns. Nevertheless, the use of Web 2.0 technologies does appear to have a general positive impact on student achievement. It is useful to note that *none* of the studies reported a detrimental or inferior effect on learning.

Second, despite the limitations, we believe that the findings are still useful because these studies attempted to examine the link between use of Web 2.0 technologies and achievement gains, an important issue given the current emphasis on accountability. Very few researchers attempt to do so. At the very least, the fact that the findings were statistically significant

suggests that there is potential for using Web 2.0 technologies for student learning. The value of the findings presented in the *Results* section of the paper is that they provide information to help teachers and instructors with actual classroom ideas to implement Web 2.0 technologies with their students. These findings could offer educators and researchers some informed directions or ideas for using the technologies to achieve specific learning goals.

Third, the positive effects are not necessarily attributed to the technologies *per se* but to how the technologies are used. Web 2.0 technologies, like any other tool, is not a silver bullet and will not independently or autonomously improve students' learning performance. Certain pedagogy and instructional strategy should be developed and practiced, along with the use of Web 2.0 technologies, in order to achieve increased students' performance. We may tentatively infer from the current findings that a dialogic, constructionist, or co-constructive pedagogy supported by activities such as Socratic questioning, peer review and self-reflection appeared to increase student achievements in blog-, wiki-, and 3-D immersive virtual world-enabled environments. With regard to podcasting, a transmissive pedagogy supported by review activities appears to enhance student learning of vocabulary words, probably because it allows students to listen to content that they missed out in class or did not fully understand many times. Podcasts should also be used to provide supplementary information or material to students rather than merely regurgitating what is already covered in lectures.

Fourth, the effects of Web 2.0 technologies should also be considered from the perspective of how one views learning. There are currently many various conceptions or views of learning available. Jonassen (2003), for example, lists several conceptions of learning including learning as the processing, storage, and retrieval of information, learning as remembering and recalling, learning as knowledge construction, and learning as social negotiation, among others. We believe the taxonomy formulated by Anderson and Krathwohl (2001) is an attempt to classify these various conceptions of learning. For example, the cognitive process category of *Remember* relates to the conception of learning as remembering and recalling, while the categories of *Create* can be viewed as relating to learning as knowledge construction.

In our review of the literature, we noticed that certain Web 2.0 technologies appear to better support certain conceptions of learning. For example, the use of wiki seems to relate most closely to the conception of learning as social negotiation. The use of 3-D immersive virtual worlds such as Second Life appears to relate to learning as construction or co-construction because it allows students to create shapes, sculpt shapes, and showcase their work to others for peer review. On the other hand, the use of podcast appears to support the conception of learning as memorization and retention due to the prevalent use of podcasting to transmit information, usually one-way from the instructor, for students to listen repeatedly to content they missed out in class. Educators should therefore be cognizant of the link between certain conceptions of learning and certain use of Web 2.0 technologies in order to make better use of the latter.

Finally, we offer the following recommendations for future research. First, studies examining the impact of Web 2.0 technologies on student learning hitherto were limited to blogs, wikis, podcasts, and virtual worlds. So far, the use of social media (e.g., Facebook and Twitter) is mainly for social networking (Hew, 2011). Can the use of Facebook, for example, be more than just social networking? We urge future studies to examine this very question.

Second, longitudinal studies are required to mitigate the novelty effects of the Web 2.0 technologies. Current studies were short in duration, ranging from 3 weeks to about one semester. Conducting longitudinal study can also provide researchers the opportunity to investigate any detrimental effects of using Web 2.0 technologies over a long period of time which has not been explored yet.

Third, no vision for the future of learning is complete until one discusses the possible convergence of digital and mobile technologies (Wagner, 2006). Possibly the greatest advantage of mobile devices is the convenience and portability that it affords to the students. Future studies should examine how Web 2.0 technologies may support students' use of mobile devices such as pocket pcs or smart phones for learning. For example, one of the challenges of using mobile devices for online collaboration is entering or reading text due to the small screen and key pad size. Web 2.0 tools such as the VoiceThread app for iPhone, iPad, or iPod, which could support an audio-based online discussion, may be a possible tool for students to use.

Finally, future research may want to explore Web 3.0 or the semantic web. As earlier indicated in this paper, Web 2.0 refers to an interactive web which facilitates collaboration among individuals. Web 3.0, on the other hand, enables computers to communicate with each other (Guistini, 2007). Perhaps, the primary feature of Web 3.0 is that it uses metadata, which is data about data (Guistini, 2007). This particular feature could potentially enable Web 3.0 to:

> "make the leap from 'display only' information to meaningful information by tagging information with descriptors. . .Further, it allows users to find relationships between tagged information using inference rules and data organizational tools called 'ontologies' that provide logic and structure to the information embedded in web pages. As a result, machines can do a lot of the information grunt work currently required of humans. When it comes to a web search, for example, [Web 3.0] makes a reasonable pass at collating, synthesizing, and cross-referencing the results for you. It does this by employing software agents that can locate and combine information from many sources to build meaningful information collages. Simply tell your agent the focus of your interest – whether a person, subject. . .and set it to roam the web, finding and distilling information an exchanging information with other agents (Ohler, 2008, p. 7).

Ohler (2008) painted several areas or scenarios by which Web 3.0 may impact learning such as knowledge construction, and personal learning network maintenance. With regard to knowledge construction, Web 3.0 could help learners to spend more time to think and participate in a learning activity, and less time searching and sifting information since it handles most of the searching grunt work. Second, Web 3.0 makes it possible for the web to become an effective and focused

information resource because it can be tailored by the learner to suit specific content area objectives. An example of a Web 3.0 application is Bing's reference search (Government Computer News., n.d.). Other educators and researchers could begin to explore other possible ways in which Bing may benefit student learning.

Appendix A

Key features of the reviewed studies.

Study	Discipline	Web 2.0 tools	Objectives	Knowledge dimension	Cognitive dimension	Pedagogy	Specific activity
Arslan and Shain-Kizil (2010) Two groups with non-random selection; sig. diff.; no E.S.	Language (undergrad.) (Turkey)	Blog	Improve English writing performance	Factual, meta-cognitive, procedural	Remember, understand, apply, create	Dialogic, construction	Peer critique and reflection
El Tantawi (2008) Two groups with non-random selection; sig. diff.; no E.S.	Dental science (undergrad.) (Egypt)	Blog	Enhance comprehension of dental terminology	Factual	Remember	Dialogic	Peer critique and reflection
Hsu and Wang (2011) Two groups with non-random selection; no sig. diff.	Language (undergrad.) (USA)	Blog	Improve reading comprehension	Factual, conceptual	Remember, understand, analyze	Dialogic, construction	Peer critique and reflection
Papastergiou et al. (2011) Two groups with non-random selection; no sig. diff.	Physical education (undergrad.) (Greece)	Blog	Improve student basketball knowledge	Factual	Remember	Dialogic, construction	Peer critique and reflection
Wong and Hew (2010) One-group pre-posttest design; sig. diff.; E.S. = 0.47	Language (5th grade) (Singapore)	Blog	Improve narrative writing	Factual, meta-cog, procedural	Remember, understand, apply, create	Dialogic, construction	Writing guide, peer critique, and reflection
Salam and Hew (2010) One-group pre-posttest design; sig. diff.; E.S. = 0.67	Social studies (10th grade) (Singapore)	Blogcast	Enhance critical thinking	Factual, conceptual, meta-cognitive	Remember, understand, evaluate, create	Dialogic, co-const.	Socratic questioning, peer and self critique

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Appendix A (*continued*)

Study	Discipline	Web 2.0 tools	Objectives	Knowledge dimension	Cognitive dimension	Pedagogy	Specific activity
Abt and Barry (2007) Two groups with random selection; sig. diff.; E.S. = 0.19	Sports science (undergrad.) (UK)	Podcast (supplementary podcasts)	Improve learning of exercise physiology concepts	Factual, conceptual	Remember, understand	Transmissive	Listen and review content
Baker et al. (2007) Two groups with non-random selection; no sig. diff.	Aviation science (undergrad.) (USA)	Podcast (lecture podcasts)	Improve learning of aviation science	-Not clearly indicated-	-Not clearly indicated-	Transmissive	Listen and review content
Carle et al. (2009) Two groups with non-random selection; sig. diff.; E.S. = 0.56	Psychology (undergrad.) (USA)	Podcast (supplementary & lecture podcasts)	Improve learning of research methods in psychology	-Not clearly indicated-	-Not clearly indicated-	Transmissive	Listen and review content
McKinney et al. (2009) Two groups with non-random selection; sig. diff.; no E.S.	Psychol. (undergrad.) (USA)	Podcast (lecture podcasts)	Improve learning of the topic perception	Not clearly indicated but assumed to be factual, conceptual	Remember, understand	Transmissive	Listen and review content
Morris (2010) Two groups with random selection; sig. diff.; no E.S.	Neuroscience (undergrad.) (UK)	Podcast (supplementary podcasts)	Enhance learning of neuroscience content	Factual, conceptual	Remember, understand	Transmissive	Listen and review content
O'Bannon et al. (2011) Two groups with non-random selection; no sig. diff.	Teacher education (undergrad.) (USA)	Podcast (lecture podcasts)	Improve learning of technology integration concepts	-Not indicated-	-Not indicated-	Transmissive	Listen and review content
Putnam and Kingsley (2009) Two groups with non-random selection; sig. diff.; no. E.S.	Science (5th grade) (USA)	Podcast (supplementary podcasts)	Enhance learning of science vocabulary	Factual, conceptual	Remember, understand	Transmissive	Listen and review content

Appendix A (*continued*)

Study	Discipline	Web 2.0 tools	Objectives	Knowledge dimension	Cognitive dimension	Pedagogy	Specific activity
Siciliano et al. (2011) Two groups with random selection; sig. diff.; no E.S.	Science – horticulture & landscape design (undergrad.) (USA)	Podcast (lecture podcasts)	Enhance understanding of facts & design techniques related to gardens	Factual, conceptual	Remember, understand	Transmissive	Listen and review content
Heafner and Friedman (2008) Two groups with non-random selection; sig. diff.; no E.S.	History (11th grade) (USA)	Wiki	Improve learning of facts	Factual	Remember, understand, analyze, create	Dialogic, co-const.	Developing an e-scrapbook, peer revision
Neumann and Hood (2009) Two groups with non-random selection; no sig. diff.	Language (undergrad.) (Australia)	Wiki	Improve report writing skills	Factual, conceptual, procedural	Understand, apply, analyze, evaluate, create	Co-constructive	Peer revision, develop research reports
Pae (2007) One-group pre-posttest design; sig. diff.; no E.S.	Language (undergrad.) (Korea)	Wiki	Improve writing	Factual, conceptual, procedural	Understand, apply, analyze, evaluate, create	Co-constructive	Peer revision, individual & collaborative writing tasks
Rick et al. (2002) Two groups with non-random selection; sig. diff.; no E.S.	Language (undergrad.) (USA)	Wiki	Improve English composition writing	Factual, conceptual, procedural	Understand, apply, analyze, evaluate	Co-constructive	Peer critique
Wichadee (2010) One-group pre-posttest design; sig. diff.; no E.S	Language (undergrad.) (Thailand)	Wiki	Improve summary writing	Factual, conceptual, procedural	Understand, apply, analyze, evaluate, create	Co-constructive	Peer revision, develop summary pieces
Junco et al. (2011) Two groups with non-random selection; sig. diff.; no E.S.	Health sciences (undergrad.) (USA)	Twitter	Improve student grades	-Not clearly indicated-	-Not clearly indicated-	Dialogic	Reflection, discussion

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Appendix A (*continued*)

Study	Discipline	Web 2.0 tools	Objectives	Knowledge dimension	Cognitive dimension	Pedagogy	Specific activity
Barab et al. (2007) One-group pre-posttest design; sig. diff.; no E.S	Science – erosion, water quality, system dynamics (4th grade) (USA)	3-D immersive virtual world (role play game world)	Teach students about scientific practices (e.g., hypothesis generation, scientific inquiry) and science concepts	Factual, conceptual, procedural, metacognitive	Remember, understand, apply, analyze, evaluate	Dialogic, constructionist	Identifying problem, gathering & analyzing data, generating hypotheses
Holmes (2007) Two groups with random selection; sig. diff.; no E.S.	Science – ecosystem (5th grade) (USA)	3-D immersive virtual world (social world)	Improve learning of ecosystem content	-Not clearly indicated-	-Not clearly indicated-	Dialogic	Conversational dialog, defining problem, generating explanations
Ketelhut and Nelson (2010) Two groups with non-random selection; sig. diff.; no E.S.	Science – environment health (7th grade) (USA)	3-D immersive virtual world (role play game world)	Improve student science inquiry, science process, & biology knowledge	Factual, conceptual, procedural	Understand, apply, evaluate	Dialogic, co-constructive	Gathering information, generating & testing hypotheses, analyzing data, discussion, and report writing
Lester and King (2009) Two groups with non-random selection; no sig. diff.	Visual-comm. (undergrad.) (USA)	3-D immersive virtual world (social world)	Improve student knowledge of visual literacy and analysis of media	Factual, conceptual	Remember, understand	Transmissive, dialogic	Read, watch & review instructor-typed out lectures, PowerPoint slides and video clips, discussion
Sourin et al. (2006) Two groups with non-random selection, sig. diff. not reported but an increase in mean exam scores reported; no E.S.	Computer graphics (undergrad.) (Singapore)	3-D immersive virtual world	Improve student scores in computer graphics	Factual, conceptual, procedural	Remember, apply, create	Dialogic, co-constructive, constructionist	Peer discussion, design of virtual objects
Villalta et al. (2011) One-group pre-posttest design; sig. diff.; E.S. = 0.5	Science – Ecology (6th grade) (Chile)	3-D immersive virtual world (role play game world)	Teach the concept of food chain	-Not clearly indicated-	-Not clearly indicated-	Dialogic	Reflection, peer discussion

Appendix A (*continued*)

Study	Discipline	Web 2.0 tools	Objectives	Knowledge dimension	Cognitive dimension	Pedagogy	Specific activity
Wrzesien and Raya (2010) Two groups with random selection; no sig. diff.	Science – Ecology (6th grade) (Spain)	3-D immersive virtual world (role play game world)	Teach natural science (e.g., the universe, earth & the ecosystem of the Mediterranean Sea	Factual, conceptual	Remember, understand, apply	Transmissive, dialogic	Listen and process information, reflection

Note: sig. diff. = significant difference; no sig. diff. = no significant difference; E.S. = effect size.

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