SELECTING MEDIA FOR EFFECTIVE LEARNING IN ONLINE AND BLENDED COURSES: A REVIEW STUDY

Abstract

As the number of online and blended learning courses offered by higher education institutions increase, a predominant issue for instructors is their design. This study focuses on the selection of appropriate media to support online and blended learning (OBL) activities. To this end, we mapped and synthesized in two consecutive systematic review studies the effectiveness of particular media formats on students' learning outcomes. Eleven empirical studies with a quasi-experimental research design and thirteen studies with randomized allocation to treatment conditions were selected for a detailed analysis. The cumulative findings indicate that ten particular media attributes are of paramount importance for effective learning in OBL courses: interactivity, navigability, (a)synchronicity, flexibility, media richness, ease of use, individualization, mobility, proximity and responsiveness. Furthermore, while the study affirms the theoretical underpinnings regarding multimedia learning and media richness, it exposed that further scrutiny in the field of media selection for application in natural settings of OBL is necessary. Future directions for research are proposed. The outcomes may be useful to OBL instructors and instructional designers in higher education.

Keywords: multimedia; media selection; online learning; blended learning; media attributes; systematic review study;

Introduction

With the expansion of high-speed internet-based technologies new educational approaches have emerged during the past twenty-five years (Rudd & Rudd, 2014; Wallace, 2003; Yang, Wang, & Chiu, 2014). In higher education, online learning environments, programs and courses have replaced traditional distance education (Perry & Pilati, 2011), while blends of classroom and online instruction emerged (Garrison & Vaughan, 2008). These instructional approaches have one thing in common: the integration of computer-delivered instruction with media formats (Adams, 2006). This gave rise to new opportunities to scaffold student learning, and eventually, the 'promise of multimedia learning' (Mayer, 2003). However, critical voices doubt whether these new possibilities are properly used to meet the expectations (Adams, 2006; Hofmann, 2006).

In this regard, one of the challenges faculty face is *how* to design online or blended courses (Alammary, Sheard, & Carbone, 2014; Branoff & Wiebe, 2009). Educators decide deliberately upon learning activities and the integration of media—physical devices used "for acquiring, storing, transporting or displaying messages" (Saettler, 2004, p. 456) —to enable students achieve educational objectives. Media selection is a prominent component of the instructional design decision making. Carliner (2000) describes media selection as "choosing the appropriate means of physically delivering the information to users (…) in print, online, through video or audiotape, or through a live connection" (p. 566). Holden and Westfall (2010) state that media selection aims to preserve instructional effectiveness through the support of a specific instructional medium.

Focus of this study is the selection of media for effective learning in online and blended learning (OBL) courses. Purpose is to present a review of empirical evidence bearing on the characteristics of particular media formats that affect learning (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Kay, 2012). This paper starts with a clarification of the notions of

media, online and blended learning. Afterwards, a background is developed which situates the problem and research context. Subsequently, detailed methodological information on both systematic review studies is provided, followed by the results and discussion. In conclusion, limitations of this study are described, and suggestions for further research outlined.

1. Conceptions of media, online and blended learning

Within an instructional design (ID) context most common definition of media is that attributed to Mayer and Moreno (2003) as part of the notion of multimedia learning and instruction, which is, "learning from words and pictures, and (…) instruction as presenting words and pictures that are intended to foster learning" (p. 43). The distinction between words and pictures as major types of media is further delineated into: printed (on-screen) or spoken text (narration), and static (photos, charts, drawing, maps, illustrations, graphs) or dynamic graphics (video, or animation) (Clark & Mayer, 2011; Mayer, 2003; Mayer & Moreno, 2002; 2003). Five commonly cited media formats originate from: text, audio, static visual, animation, and video. However, there seems to be considerable variation in how the various media formats are termed as well as segmented (Clark & Mayer, 2011; Plass, Moreno, & Brünken, 2010).

Both online learning and blended learning are ambiguously defined in literature. This terminological quandary persists to this day (Moore, Dickson-Deane, & Galyen, 2011). Among others, Ananthanarayanan (2014) stated that "online learning is interpreted or understood from a variety of perspectives depending on the delivery mechanisms, communication modalities, content types and access structures" (p. 3). Several contributions make reference to web-based instruction or learning (e.g., Williams, 2002), internet learning, e-learning, networked learning, distributed learning (Ananthanarayanan, 2004; Holden & Westfall, 2010). E-learning has been known to be equated with, and at the same time considered a subcategory of online learning (Moore et al., 2011). Means, Toyama, Murphy, Bakia, and Jones (2010) ascertained that online

learning is often used interchangeably with distance learning. Moore, Dickson-Deane and Galyen's review of literature (2011) indicated that authors tend to relate online learning to distance education, some identifying it as its most recent version, but overall "appear unsure in their own descriptive narratives" (p. 130). Ananthanatayanan (2014, p. 242) describes online learning as "an instructional format that is mediated by some form of technology, typically the internet and is characterized by geographical and, sometimes, temporal separation between instructor and student". In line with Wallace (2003) online courses are defined as courses that are offered entirely through the internet.

There is also wide variety of denotations for blended learning (BL) (Bernard et al., 2014; Holden & Westfall, 2010), ranging from a mix of various web-based technologies or pedagogical approaches, a combination of some form of instructional technology with face-to-face instruction or as a mix of learning and working (Bernard et al., 2014). Whitelock and Jelfs (2003) identified three definitions of blended learning: (1) "the integrated combination of traditional learning with web-based on-line approaches", (2) "the combination of media and tools employed in an e-learning environment", and (3) "a combination of a number of pedagogical approaches, which is not necessarily dependent on the use of learning technologies" (p. 99). The concept is used synonymously to hybrid learning, blended networked learning, mixed-mode learning and flexible learning (Nowell, 2011; Picciano, 2007; Wang, Hang, & Yang, 201$5). Within ID research, BL is commonly defined as a mix of classroom and online instruction (Bernard et al., 2014; Holden & Westfall, 2010) or the use of web-based instruction as a supplement to face-to-face instruction (Mishra, 2002). On the analogy of Halverson, Graham, Spring, and Drysdale (2012) blended courses qre courses that combine online and face-to-face learning activities. Higher institutions need to uncover the transformative prospects of blended learning, and identify the optimum way to apply both online learning and face-to-face instruction (Garrison & Kanuka, 2004). Blended learning

retains the traditional values of higher education and utilizes innovative instructional media for effective learning (Dziuban, Hartman, & Moskal, 2004; Garrison & Kanuka, 2004). The flexibility of blended learning allows teaching and learning to occur at the convenience of learners and instructors, while it also facilitates creative, complex and critical thinking skills (Garrison & Kanuka, 2004), improves learners' dispositions and learning outcomes (Cheston, Flickinger, & Chisolm, 2013; Liu et al., 2016; Mc Cutcheon et al., 2015) and reduces attrition rates (Dziuban, Hartman, & Moskal, 2004).

2. Selecting media for effective learning

Clark posited in 1983 that media do not impact learning, rather instructional method affects learning. This led to the media debate, as Kozma (1994) argued that media have specific attributes that interact with the learner and the instructional task which fosters learning. As stated in Kozma (1994), "particular media formats possess particular characteristics that make them both more and less suitable for the accomplishment of certain kinds of learning tasks" (p. 2). This implies that the characteristics which a media format possess capacitates the media format to enhance the process of learning. Media enrich learning when they are properly designed with adequate instructional methods (Blaschke, 2014). The strength of instructional media vary; some are more apt than others (Holden & Westfall, 2010). Instructional strategies, learner and cost aspects of each instructional medium should be evaluated, in order to ensure that relevant media are chosen for the achievement of specific educational objectives (Hirumi, Bradford, & Rutherford, 2011; Holden & Westfall, 2010; Kerres & De Witt, 2003). In addition, "media attributes determine the selection of media" (Hossain, Kim, Lee & Kim, 2012, p. 304). Previous studies distinguished several of such attributes, including interactivity, flexibility, media richness, synchronicity, navigability, responsiveness, symmetry, display, participation, complexity, ease of use, reciprocity, demonstrability and individualization (Chen & Jang,

2013; Holden & Westfall, 2010; Hossain et al., 2012; Huang, 2003; Nugraini, Choo, Hin, & Hoon, 2013).

Two theories have been predominant in research on effective learning in media-rich environments: the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2003; Mayer, 2008; Mayer & Moreno, 2002) and the Media Richness Theory (MRT) (Daft & Lengel, 1986).

CTML-research findings show that the addition of images to verbal-only instruction fosters deeper learning (Mayer, 2001, 2003). The 'promise of multimedia learning' refers to the fact that "meaningful learning occurs when students are able to make connections between corresponding visual and verbal representations in working memory" (Mayer & Moreno, 2002, p. 113). Presenting both words and pictures proved to be more effective than the use of a single medium, nevertheless, multimedia presentations vary in their level of effectiveness (Clark & Mayer, 2011; Mayer & Moreno, 2002). The addition of images in itself does not automatically improve learning or comprehension, it is necessary to carefully consider the conditions under which the addition of 'pictures' - be it static or animated visuals, graphics or video, actually fosters deep learning in practice (Mayer, 2003). This view has been thoroughly reflected in literature (Castaño-Muñoz, Duart, & Sancho-Vineusa, 2014; Holden & Westfall, 2010; Kember, McNaught, Chong, Lam, & Cheng, 2010). Van Merrienboer, Clark, and de Croock (2002) also stated that "the development of learning environments and production of instructional materials are often media specific" (p. 58). The MRT, as stated by Lengel and Daft (1984) posits: "Media richness is defined as a medium's capacity to process information. Richness is the relative ability of information to influence or change mental representations and thereby to facilitate learning" (p. 7-8). Further, "Information richness is defined as the ability of information to change understanding within a time interval" (Daft & Lengel, 1986, p. 560). The richness of a media format depends on its ability to enhance learning, clarify and communicate ambiguous messages. Richer media allow users to communicate easily,

comprehend equivocal and ambiguous messages, and carry out equivocal tasks better, while leaner media are appropriate for less equivocal tasks (Dennis & Kinney, 1998).

In sum, in order to support and improve learning performance, media are selected based on instructional methods, media attributes and learner characteristics (McLaughlin, Rogers, Sierra, & Fisk, 2007; Yang et al., 2014). Additionally, it is essential to consider the type of cognitive objectives when choosing media for instruction; synchronous media (webcasting, audio, video, chat) are more suitable for higher cognitive level objectives, while asynchronous media such as e-mail and discussion boards seem to be more appropriate to reach lower cognitive level objectives (Holden & Westfall 2010).

3. Purposes of the study and research questions

Despite the multitude of publications regarding media usage in OBL environments and their beneficial outcomes on learners' motivation, retention and (meta-)cognitive development (e.g., Bronack, 2011; Blaschke, 2014; Choi & Johnson, 2005; Conole & Alevizou, 2010; Sahin, 2010; Tess, 2013), different authors pointed out that appropriate guiding principles for media selection are missing (Adams, 2006; Alammary et al., 2014; Carr-Chellman & Duchastel, 2000). Moreover, previous review studies in the area show a limited explicit focus on empirical studies researching learning gain. As is the case with Kay's review on video podcasts (2012), for example, a number of authors mirrored media research trends and examined a wide scope of research designs (e.g., McElhaney, Chang, & Chiu, 2014). Some covered the impact and variability of online or blended learning versus face-to-face instruction (e.g., Bernard et al., 2014; Cook, Garside, Levinson, Dupras, & Montori, 2010; Means et al., 2010). Means et al., 2010, focused more narrowly on experimental and quasi-experimental studies relating to effectiveness of practices in media selection and use, but primarily paid attention to issues of synchronicity. Therefore, one common recommendation for further research suggests that more

analysis is needed of empirical evidence bearing on the characteristics of particular media formats that affect learning (Bernard et al., 2014; Kay, 2012).

In the absence of a synthesis of (quasi-)experimental research conducted on effectiveness and applicability of different media formats for ID purposes within settings of OBL, this systematic review was carried out. To our knowledge, no such research was available at the onset (January 2014). The study seeks to explore the following research questions:

RQ 1. What is the scope of previous empirical research in the OBL field?

RQ 2. What is the synthesis of empirical evidence of the effectiveness of particular media formats on student learning outcomes in OBL?

RQ3. What attributes should be considered when selecting the most appropriate media format for OBL?

4. Methodology

4.1. The systematic review study approach

The evidence from experimental and quasi-experimental studies conducted in the past decade on the use and effectiveness of different types of media within OBL courses was reviewed systematically. Two consecutive studies investigated the scope of empirical research in this field, and synthesized results about the effectiveness of specific media formats on learning outcomes, in order to identify media attributes that should be considered for OBL course design purposes. Auxiliary, this study intends to derive evidence-based recommendations regarding the appropriate selection of media for OBL in natural learning settings. These could be beneficial to practitioners, policy makers and scholars.

A systematic review study (SRS) is a method that rigorously identifies, appraises and synthesizes available research evidence, in order to answer a stated research question (Bettany-Saltikov, 2010). According to Gough (2007), systematic synthesis "is a set of formal processes

for bringing together different types of evidence so that we can be clear about what we know from research and how we know it" (p. 214). It is different from a scoping review, which is conducted prior to a systematic review, and not in a systematic way (Gough, Oliver, & Thomas, 2012). SRSs are carried out in order to: (1) discover any lacuna in research and propose areas where further research is needed, (2) outline existing empirical evidence of a certain treatment, (3) investigate the extent to which empirical evidence refutes or conforms a theoretical hypothesis, (4) offer a framework in which new research can be aptly positioned (Kitchenham, 2004). Systematic reviews are used to advise practice and policy decisions (Gough et al., 2012).

For this study, the SRS approach as outlined by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) (2010) was applied. The Centre developed procedures for conducting relevant, high-quality systematic reviews: (1) setting the scope and strategies for the review, (2) searching for studies, (3) screening studies to ensure they fit the scope of the review, (4) describing studies for mapping and synthesis, (5) appraising the data and synthesizing study findings, (6) drawing conclusions and making recommendations.

4.2. The inclusion and exclusion criteria

To be included in the reviews an article needed to report on an empirical investigation. In each study, the impact of particular media formats embedded in an online or blended learning environment is assessed. Overall, we covered roughly a decade of research in this field, which coincides with the rise of BL in higher education (HE) contexts, and the use of this term at academic conferences and in publications (Bonk & Graham, 2006). Only intervention studies based on a treatment-control design that used objective measures for learning performance were included, instead of student self-reports, which may introduce biases. A specific exclusion criterium was set on studies measuring exclusively learner satisfaction, perception or

motivation. Excluded from our scrutiny were studies comparing conditions with and without media, as this issue has already been sufficiently covered (Branoff & Wiebe, 2009; McFarlin, 2008). In Study 1 (SRS1), the search was limited to peer-reviewed studies published between 2005 and June 2015, written in English. Study 2's review (SRS2) consisted of English-written studies published between January 2006 and March 2016 in peer-reviewed journals. SRS1 incorporated studies with a randomized allocation experimental design, while SRS2 focused solely on quasi-experimental investigations. Qualitative or mixed-method were excluded in SRS1 and SRS2, as well as reports with regard to populations with special educational needs (SRS1 and SRS2) and K-12 learners (SRS2).

4.3. Data collection and analysis

A comprehensive search strategy was conducted to retrieve relevant studies, including an online database search, manual screening of journals and of citation references (see Appendix A for databases and journals searched). Figure 1 shows how the selection of articles was done in both studies, and what results it yielded.

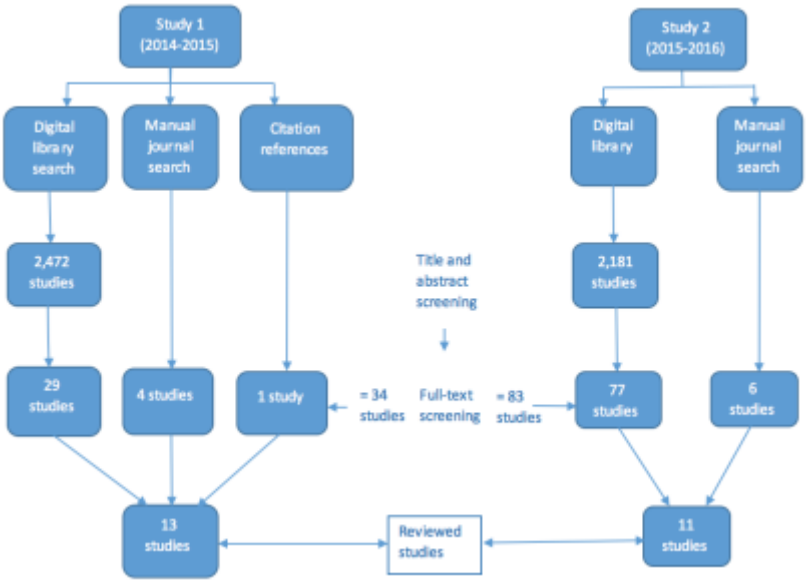

Figure 1. Search and selection strategy of the systematic review studies

During the first study (SRS1), in total, 2,472 studies were screened on title and abstract, only 34 studies passed the first screening phase to be screened on full-text, and then 13 studies that fit the inclusion criteria were coded and analyzed. In the second study (SRS2), overall, 2,181 studies were retrieved. These studies were firstly screened based on title and abstract, of which 83 were selected for full-text screening, then 11 studies met all inclusion criteria and were selected for further review.

Each of the selected studies were described in line with the EPPI-Centre keywording (coding) strategy (2010), in order to accurately represent details of the generic variables and results. The generic variables stated in this study are: participants (sample size, age and gender), subject area, media type compared, media characteristics, learning environment, study location, assessment and primary outcome (see Appendix B and C). Subsequently, the findings of the selected studies were synthesized and integrated narratively using the EPPI-Centre's strategy.

Results

1. <u>The scope of the empirical research: sample, subject areas, settings and media</u>

Except for one study conducted in a primary school (Lin & Tseng, 2012), the participants in SRS1 were all higher education (HE) students. Their age ranged from 17 years and above. Studies were conducted in Austria (1), China (1), South Korea (2), the UK (1) and the USA (6), although the location was not indicated in two studies. Besides three studies where participants' gender was not specified, other studies comprised both male and female students. The subject areas assessed in the selected studies are: Physical Education (1), ICT (2), Mathematics (1), PSE (1) Business Studies (1), Science (4), Literacy (1), Other (2). The studies' sample size ranged from 30 to 582 students. Studies included in SRS2 were all carried out in HE institutions, and handled media in online (7), blended (3) or both types (1) of learning

environments. The sample size ranged from 30 to 318 students, mean age of participants is 22 years and above, although it was not specified in seven studies. The sample consisted of both males and females, but was not indicated in four studies. One study's location was not stated, other studies were carried out in the USA (6), Turkey (2), Canada (1) and Ireland (1). The reviewed studies were classified into the following subject areas: Sciences (2), ICT (3), Social sciences (2), Business studies (2), Education (1), and Mathematics (1).

A majority of the reviewed studies in SRS1 compared text, static visual, audio, animation and video (Doo, 2005; Griffin, Mitchell, & Thompson, 2009; Heo & Han, 2013; Kaplan & Wu, 2006; Kößler & Nitzschner, 2015; Lin & Dwyer, 2010; Lin & Tseng, 2012; Yadav et al., 2011; Zhang, Zhou, Briggs & Nunamaker, 2006). Variations of text and static visuals were investigated by Sung and Mayer (2012), while Hilbelink (2009) made a distinction of static visuals based on 2D and 3D images. Video with narration was compared on segmentation and signaling (Ibrahim, Callaway, & Bell, 2014). Cooper and Higgin (2015) compared videos with various length. Student performance is evaluated through multiple choice test and performance assessment. Some studies assessed additionally student satisfaction (5) and student perceptions of learning (5). In SRS2, Sahasrabudhe and Kanungo (2014) compared text, graphics, sound, talking-head and video/animation at four different levels. Video and non-video were examined by Evans and Cordova (2015), Hegeman (2015) juxtaposed instructor-generated videos and text-based multimedia, also audio and video casting were analysed by Han (2013). Similarly, a comparison was made between video and text, personalized and non-personalized videos, aural and non-aural media, question-embedded interactive video and interactive video (Craig & Freihs, 2013; McGovern & Baruca, 2013; Ridgway et al., 2007; Vural, 2013). A nuanced dimension was taken in three studies, which compared unconventional media formats such as, Internet-based continuing medical education (CME) instruction: Scheduled group learning format with eCME on Demand format (Curran, Fleet, & Kirby, 2010); Mobile learning (m-

learning) adaptive tool with e-learning (Garcia-Cabot, de-Marcos, & Garcia-Lopez, 2015) and forms of online tutorials with problem-based learning (PBL) guidance (Baturay & Bay, 2010). The effectiveness of media formats on students' learning outcomes, was assessed through exams, quizzes, assignments and tests. Certain studies also measured student satisfaction (3), student self-efficacy (2), student perceptions (3) and student confidence (2).

2. Empirical evidence of effectiveness of media formats

Generally, most of the reviewed studies in SRS1 recorded better student learning performance in one of the treatment conditions (see Table 1). Nevertheless, four studies indicated no evidence of greater effectiveness of one condition over another. Yadav et al. (2011) examined student performance in three different groups (a) text, (b) text with video/animation, and (c) video; no significant difference was recorded. Heo and Han (2013) also measured three groups of students (a) text with static visuals, (b) text with video, (c) video; which showed no significant difference too in student performance. Equally, Cooper and Higgins (2015) compared longer video with shorter video, there was no significant difference between both groups. Doo (2005) measured students learning performance in four groups (a) text, (b) static visuals with audio, (c) video, and (d) audio, none had a significant effect on learning performance. The effectiveness of text with static visuals versus video (interactive and non-interactive video) was assessed by Zhang et al. (2006). The interactive video group performed significantly higher than other groups, but there was no significant difference between the non-interactive video group and the text with static visual group. This seems to support the idea by Clark (1983) that different combinations of media might be able to deliver the same result. Griffin et al. (2009) evaluated static visuals synchronized with audio and static visuals separate from audio, the synchronized group had significantly higher scores; this appears to substantiate the *temporal contiguity principle* (Mayer, 2003; Moreno & Mayer,

1999). Further, text only, text and static visual, with text and video/animation were investigated (Lin & Tseng, 2012), the video group scored significantly higher that the text and static visual group. Also, Lin and Dwyer (2010) examined text and static visual, text and video/animation, static visual only, with animated visual; the animated visual group scored higher. Both studies seem to be in line with both the multimedia principle (Mayer, 2003) and media richness theory (Daft & Lengel, 1986), thus, richer media yield greater learning performance. Sung and Mayer (2012) compared text, text and static visual (instructive, decorative and seductive graphics); the instructive graphics group outperformed other groups. This affirms the multimedia effect by showing that the addition of static visuals to text improves test performance, also it seems to confirm the coherence principle that the addition of seductive graphics can have negative effect on learning outcomes (Mayer, 2008). Similarly, video with segmentation and signaling, video with segmentation, and video in continuance were evaluated by Ibrahim et al. (2014); the segmentation and signaling group scored higher. This verifies the principle of segmentation (principle for managing essential processing) and signaling (principle for reducing extraneous processing) (Mayer, 2008), as video with segmentation and signaling significantly influence learning performance in comparison to linear video. Furthermore, three selected studies examined less common media combinations. Kößler and Nitzschner (2015) juxtaposed text and video (funny video and serious video), the scores of the humorous video group was significantly different from the text and serious video groups. This appears to confirm findings about positive effects of humour for aiding learning process and diminishing cognitive load (Jonas, 2012).

Table 1

Summary of the effectiveness of media formats in the reviewed studies

Article	Evidence of greater effectiveness of one condition over another	Significant results
Baturay & Bay (2010)	Yes	Online tutorial AND problem-based learning guidance > Online tutorial
Cooper & Higgins (2015)	No	Short video = Long video
Craig & Freihs (2013)	Yes	Video > Text (HTML)
Curran, Fleet & Kirby (2010)	Yes	Scheduled group learning format > eCME on-demand format
Doo (2005)	No	Text only = Static visual = Video with narration = Audio only
Evans and Cordova (2015)	Yes	Video (PowerPoint slides and lecture notes with a classroom of students) > Non-video (PowerPoint slides and lecture notes)
Garcia-Cabot et al. (2015)	Yes	m-learning adaptive tool > e-learning
Griffin, Mitchell & Thompson (2009)	Yes	Static visuals synchronised with audio > Static visuals separate from audio
Han (2013)	Yes	Video casting (with non-verbal and social cues) > Audio
Hegeman (2015)	Yes	Instructor-generated video > Text-based multimedia (Publisher-generate or instructor-generated)
Heo & Han (2013)	No	Text AND static visuals = Text AND video/animation = Video only
Hilbelink (2009)	Yes	3D stereo image > 2D image
Ibrahim, Callaway & Bell (2014)	Yes	Video with segmentation AND signaling > Video with segmentation > Video in continuance
Kaplan & Wu (2006)	Yes	Static visual with motion cues > Animated visual > Static visual without motion cues > Text only

Kößler & Nitzschner (2015)	Yes	Humorous video > Text only = Serious video
Lin and Dwyer (2010)	Yes	Animated visual (with or without text) > Static visual (with or without text)
Lin & Tseng (2012)	Yes	Text AND video/animation > Text AND static visual(s) = Text only
McGovern and Baruca (2013)	Yes	Personalized video > F2F class AND personalized video > F2F class AND non-personalized video
Ridgway et al. (2007)	Yes	Aural group (text AND graphics AND voice-over) > Non-aural group (text AND graphics)
Sahasrabudhe and Kanungo (2014)	Yes	Group 1: Text AND graphics AND video/animation = Text AND graphics AND sound > Text AND graphics. Group 2: Text AND graphics AND video/animation = Text AND graphics AND talking-head > Text AND graphics AND sound.
Sung & Mayer (2012)	Yes	Text AND instructive graphics > Text AND seductive graphics = Text AND decorative graphics = Text only
Vural (2013)	Yes	Question-embedded interactive video > Interactive video
Yadav et al. (2011)	No	Video only = Text AND video/animation = Text only
Zhang, Zhou, Briggs & Nunamaker (2006)	Yes	Interactive (segmented) video > Non-interactive video = Text AND static visual(s)

**Note.* The '=' sign denotes cases where no statistically significant difference was found in the effect of media choice on performance. Where a significant difference was found, 'X > Y' denotes that media X resulted in better performance than media Y.

Hilbelink (2009) made a comparison between static visuals (3D stereo imaging and 2D images). The 3D group had significantly higher scores than the 2D group, affirming the applicability of MRT. Kaplan and Wu (2006) investigated text, static visual, static visual with motion cues, animated visual, and interactive animated visual. The animation group outperformed text and static visual groups on transfer and training problems, also, the motion cues group outperformed all other groups on transfer problems. The addition of motion cues, further supports the MRT.

The reviewed studies of SRS2 showed evidence of the effectiveness of specific media formats in one treatment condition over another. Vural (2013) made a comparison between question-embedded interactive video and interactive video. Students in the question-embedded group scored significantly higher than students in the interactive video group. This implies that students' learning can be enhanced by question-embedded videos, and is in line with the media richness theory and the personalization effect (Mayer, 2003). Video and text (HTML) were analysed by Craig and Freihs (2013), students who used video tutorials performed better than students who used HTML tutorials. This confirms the cognitive theory of multimedia learning (Mayer, 2003). In addition, McGovern and Baruca (2013) investigated the effects of personalized and non-personalized videos on student performance. Students were divided into three groups: (group 1) online classes with the professor-of-record appearing in the video, (group 2) face-to-face classes with the professor-of-record appearing in the video, (group 3) face-to-face classes without the professor-of-record in the video. Students in group 1 scored higher than students in group 2, and group 2 students scored higher than group 3 students. This also supports the personalization effect. Similarly, Curran et al. (2010) compared internet-based CME instruction formats. The scheduled group learning students scored significantly higher than students in the eCME on-demand format. This affirms the active learning assumption (Mayer, 2003). Equivalently, aural group learners and non-aural group learners

were measured. Ridgway et al. (2007) discovered that grades of learners in the aural group were significantly higher than those in the non-aural group. This finding seems to contradict the information delivery theory (Mayer & Moreno, 2002).

The treatment conditions of the following studies though effective, had little variations across forms of assessment and media combinations. Firstly, the study by Sahasrabudhe and Kanungo (2014) grouped four levels of media combinations and compared them among two sections. Section 1: TG, TGS and TGVA, Section 2: TGS, TGTH and TGVA. When compared, there was significant difference in learning outcomes across the levels, although in section 1, learning effectiveness increased up to TGS, there was no learning increase in TGVA. Also in section 2, there was increase in student performance up to TGTH, but no further increase in TGVA. This validates the cognitive load theory which holds that 'presenting too many elements to be processed in visual or verbal working can lead to overload in which some of the elements are not processed.' (Mayer & Moreno, 2002, p. 111). Secondly, instructor-generated videos and text-based multimedia (publisher-generated or instructor-generated) were compared by Hegeman (2015). In online quiz, online exam, handwritten midterm exam and handwritten final exam, students in the text-based group scored significantly lower than students in the video group. While in the online homework, the text group scored higher than the video group, though there was no significant difference. This verifies the personalization effect. Thirdly, Evans and Cordova (2015) analysed the effect of video and non-video. Students in both groups scored equally on the first exam, albeit, on the next three exams, students in the video group performed better than the non-video group. This reaffirms the multimedia effect (Mayer, 2003). Additionally, Han (2013) examined audio and video casting conveying nonverbal social and emotional cues. There was no significant difference in the midterm grades of both groups, but in the final exam the video group had higher scores. This study verifies media richness theory and the embodiment principle (Mayer, 2014). Garcia-Cabot et al. (2015), compared m-learning

adaptive tool and e-learning. Students of the m-learning group outperformed the e-learning group in practical assignments and in the overall score, but no difference was observed in the examination scores. Lastly, online tutorials combined with problem-based learning (PBL) guidance and online tutorials without PBL guidance was investigated by Baturay and Bay (2010). The intervention group scored significantly higher than the control group in the pre and post-tests, but the control group had higher assignment grades. However, the midterm and final exam scores did not indicate any difference between both groups. This seems to support Clark and Mayer's (2011) knowledge construction view which asserts that 'it is not good enough to deliver information to the learner; instructors must also guide the learner's cognitive processing during learning, thereby enabling and encouraging learners to actively process the information' (p. 79). It is also in line with the active learning assumption which aids problem-solving transfer (Mayer, 2003).

3. Attributes to consider when choosing appropriate media formats for OBL

The reviewed studies in SRS1 appear to confirm certain principles in line with the CTML and the MRT, which serves as theoretical underpinning for instructional design in OBL. Overall, the multimedia principle was upheld, as videos and animated visuals added to other media formats in most studies fostered deeper learning. Richer media formats that were used to enhance student learning performance in OBL, thus supporting the MRT (Griffin et al., 2009; Hilbelink, 2009; Ibrahim et al., 2014; Kaplan, 2006; Kößler & Nitzschner, 2015; Lin & Dwyer, 2010; Lin & Tseng, 2012; Zhang et al., 2006). Based on the articles, it seems that for conditions that require tasks such as probability solving (Kaplan, 2006), analysis of medical structures or functions (Lin & Dwyer, 2010; Hilbelink, 2009) richer media that support mental modeling, such as animations, visuals with motion cues, and 3D stereo-imaging, are recommended. Further, interaction and interactivity were identified in studies as an essential attribute of media in the designing of OBLE (Kaplan, 2006; Zhang et al., 2006). While the study participant and

setting features tend to be homogenous, SRS2 discovered a wide variety of media attributes that enhance students' learning outcomes in OBL. The media characteristics identified in the study of Han (2013) are interactivity, synchronicity, proximity (instructor's nonverbal cues) and media richness. Flexibility, media richness and interactivity were also observed (Vural, 2013). Ease of use, interactivity, flexibility, individualization (personalization) and mobility were found in the study by Garcia-Cabot et al. (2015). Individualization (personalization) was also identified in McGovern and Baruca (2013). Subsequently, navigability and interactivity were ascertained (Craig & Freihs, 2013). Further, the following media features were detected in the article of Hegeman (2015); responsiveness, interactivity, individualization, proximity (instructor's teaching presence) and flexibility. Flexibility and media richness were found (Evans & Cordova, 2015). Richness of media was also the observable media characteristic in the work of Sahasrabudhe and Kanungo (2014). In addition, asynchrony, flexibility and interactivity were the visible media features in the study of Curran et al. (2015). Interactivity, media richness and ease of use was discover in Ridgway et al. (2007). Lastly, in Baturay and Bay (2010), interactivity and (a)synchronicity were identified.

Discussion

Based on the above sections, and merging insights of both SRSs, it appears the scope of empirical research carried out in the field is limited. Most of the reviewed studies were conducted in the US, and samples included almost exclusively HE students. This indicates a dearth of empirical studies on this topic in other parts of the worlds, hence, the findings are likely to be context-specific and cannot be generalized to other locations or populations. Furthermore, the review indicates the dominance of studies in ICT, Sciences and Business studies, and a lack of studies of this nature in subject areas such as Vocational Education, Humanities and Environmental Sciences. Therefore, in order to broaden the scope there is a

great need for further scrutiny in different locations, with different populations and a series of other subject fields.

Despite the limited amount of reviewed studies (24 in total), numerous media formats and combinations were found, as well as evidence that the use of specific media formats enhances the effectiveness of instruction on students' learning outcomes in OBLEs. Majority of the selected studies employed the use of videos and multiple media formats, this is in line with Mayer and Moreno (2002), that greater understanding can be enhanced through the use of multimedia presentations. However, the findings of certain studies (Cooper & Higgins, 2015; Doo, 2005; Heo & Han, 2012; Yadav et al., 2011) showed no evidence of greater effectiveness of one media condition over another on students' learning performance in OBLE. This contradictory findings are not entirely unexpected in light of some conflicting accounts on the effectiveness of online learning environments (Clark, Yates, Early & Moulton, 2010), although, it is an issue for further investigation. In conclusion, media do not stand alone, effective and efficient learning occurs when instructional methods and media formats are adequately integrated into the teaching and learning process.

The cumulative findings indicate that ten particular media attributes are of paramount importance for effective learning in OBL courses: interactivity, navigability, (a)synchronicity, flexibility, media richness, ease of use, individualization, mobility, proximity and responsiveness. Accordingly, it can be inferred that media characteristics identified in the selected studies enhanced the learning process, which led to improved effectiveness in students' learning outcomes. This affirms the findings of previous studies which discovered that flexibility, asynchrony, interactivity and richness of media improves learning in OBL (Castaño-Muñoz et al., 2014; Cheston et al., 2013; Choi & Johnson, 2005; Kay, 2012; Kember et al., 2010).

Interactivity, media richness and flexibility are the most included media attributes identified in the reviewed studies; this reveals the importance of interaction between the instructor, the learner and the instructional content. It signifies how the use of rich media formats aids the clarification of ambiguous information and enhances learning. Moreover, flexibility permits learning to occur anywhere and anytime, at the pace and convenience of the student which is a major advantage of OBL. It is noteworthy that the attributes vary across media formats and are task-specific. Therefore, it is recommended that instructional designers should match methods and tasks to befitting media formats, bearing in mind the intended learning objective(s).

The results of this study raises the awareness and importance of considering media attributes in the designing of effective OBLEs. The findings can be linked to the CTML, as the selected studies applied both visual and verbal representations, which led to improved students' learning outcomes. This shows the cognizance of the CTML among OBL instructors. The results can also be related to the MRT, as reviewed studies used rich media formats which are capable of clarifying equivocal instructional content, and thus resulted in effective learning. In addition, there are certain similarities and differences in the findings of both reviews. Firstly, studies included in both reviews upheld the MRT and the CTML. Secondly, both studies identified interactivity and richness of media as important attributes of media. Thirdly, they indicated the dearth of empirical studies on this topic in other regions than the US. Most studies in both reviews showed evidence of greater effectiveness of one media treatment condition over another on students' learning outcomes. However, four studies in SRS1 indicated equal effect of the compared media formats on students' learning performance.

Further, McLaughlin et al. (2007) stated that it is important to consider learners' age when selecting a medium, because age varies and thus, influence learners' decision to choose essential information and overlook extraneous information. Therefore, media selection studies

on K-12 and special needs students is required, to enable the design of specific and effective OBLEs that will match their needs and abilities. Hirumi et al. (2011) considered additional factors for selecting media, which includes cognitive level, cost, content stability and instructional strategy.

There are some limitations of the study. Both reviews retrieved few articles which matched the inclusion criteria perfectly, this limits the findings and makes generalization problematic. During the full-text screening process, the methodology of several studies was unclear, hence they were excluded, and this might have led to the neglect of useful articles. Also, the review only considered articles written in English, there might be studies in other languages with interesting findings that could have been important to this research. There are also few empirical studies on media selection, most of the studies found were mainly on effectiveness. It can be postulated that there is the necessity of further studies with a longer time frame, in order to retrieve articles from other databases and scientific journals. This will broaden the knowledge base of this topic. The high homogenous results found in both reviews signify that there is great need for studies of this nature in different countries and subject areas. A different systematic review approach might yield different results. Systematic reviews of studies with mixed method and qualitative research designs on this topic is also required.

Conclusions

With the increase of OBL courses offered in educational institutions, designing an effective learning environment has been a major concern for instructors. This study tackled three research questions on media selection. The findings presented above indicate the effectiveness of media formats on student learning outcomes, the media formats assessed and their attributes. By means of two consecutive systematic review studies, it offered greater insight into the research being conducted in the field, mapping study characteristics such as

sample population, country, educational setting, media formats assessed, subject areas used for content, type of assessment and learning outcome variables.

Based on both reviews, we conclude attributes that should be considered when choosing media types in the designing of OBLEs, include: interactivity, navigability, (a)synchronicity, flexibility, media richness, ease of use, individualization, mobility, proximity and responsiveness. The findings depict strong and valid theoretical and practical relevance of media in learning. It can be inferred from both reviews, that media attributes influence the achievement of the learning objective, and media enhance effective student learning outcomes when properly integrated into the instructional process in OBLEs. It offers evidence-informed suggestions and indicates the importance of media selection in the designing of OBLEs, which is informative and beneficial to practitioners, policy makers and researchers.

References

Adams, J. (2006). The part played by instructional media in distance education. *Studies in Media and Information Literacy Education, 6*(2), 1-12.

Alammary, A., Sheard, J., & Carbone, A. (2014). Blended learning in higher education: Three different design approaches. *Australasian Journal of Educational Technology, 30*(4), 440-454.

Ananthanarayanan, V. (2014). Social presence in culturally mediated online learning environments. In R. D. Wright (Ed.), *Student-Teacher interaction in online learning environments* (pp. 1-21). Texas, USA: IGI Global.

Baytak, A. (2010, February). *Media Selection and Design: A Case in Distance Education.* Paper presented at the Akademik Bilişim Konferanslari, Muğla, Turkey. Retrieved from http://ab.org.tr/ab10/bildiri/12.pdf

Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: from the general to the applied. *Journal of Computing in Higher Education, 26*, 87-122.

Bettany-Saltikov, J. (2010a). Learning how to undertake a systematic review: Part 1. *Nursing Standard, 24*(50), 47-55.

Blaschke, L. (2014). Using social media to engage and develop the online learner in self-determined learning. *Research in Learning Technology, 22*.

Bonk, C. J., & Graham, C. R. (2006). *The handbook of blended learning: Global perspectives, local designs.* San Francisco, U.S.A: Pfeiffer.

Branoff, T., & Wiebe, E. (2009). Face-to-face, hybrid, or online?: Issues faculty face redesigning an introductory engineering graphics course. *Engineering Design Graphics Journal, 73*(1), 25-31.

Bronack, S. C. (2011). The role of immersive media in online education. *The Journal of Continuing Higher Education, 59*(2), 113-117.

Carliner, S. (2000). Physical, cognitive, and affective: A three-part framework for information design. *Technical Communication, 47*(4), 561-576.

Carr-Chellman, A., & Duchastel, P. (2000). The ideal online course. *British Journal of Educational Technology, 31*(3), 229-241.

Castaño-Muñoz, J., Duart, J. M., & Sancho-Vinuesa, T. (2014). The Internet in face-to-face higher education: Can interactive learning improve academic achievement?. *British Journal of Educational Technology, 45*(1), 149-159.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and instruction, 8*(4), 293-332.

Chen, H-Y., & Jang, S-J. (2013). Exploring the reasons for using electric books and technologic pedagogical and content knowledge of Taiwanese elementary mathematics and science teachers. *The Turkish Online Journal of Educational Technology, 12*(2), 131-141.

Cheston, C. C., Flickinger, T. E., & Chisolm, M. S. (2013). Social media use in medical education: A systematic review. *Academic Medicine, 88*(6), 893-901.

Choi, H. J., & Johnson, S. D. (2005). The effect of context-based video instruction on learning and motivation in online courses. *American Journal of Distance Education, 19*(4), 215-227.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*(4), 445-459.

Clark, R. C. & Mayer, R. E. (2011). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. San Francisco, USA: John Wiley & Sons.

Clark, R. E., Yates, K., Early, S., Moulton, K., Silber, K. H., & Foshay, R. (2010). An analysis of the failure of electronic media and discovery-based learning: Evidence for the performance benefits of guided training methods. *Handbook of training and improving workplace performance*, *1*, 263-287.

Conole, G., & Alevizou, P. (2010). A literature review of the use of Web 2.0 tools in Higher Education. *A report commissioned by the Higher Education Academy*.

Cook, D. A., Garside, S., Levinson, A. J., Dupras, D. M., & Montori, V. M. (2010). What do we mean by web-based learning? A systematic review of the variability of interventions. *Medical Education, 44*, 765–774.

Cook, D. A., Levinson, A. J., Garside, S., Dupras, D. M. Erwin, P. J., & Montori, V. M. (2010). Instructional design variations in internet-based learning for health professions education: A systematic review and meta-analysis. *Academic Medicine, 85*(5), 909-922.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management science, 32*(5), 554-571.

Dennis, A. R. & Kinney, S. T. (1998). Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality. *Information Systems Research, 9*(3), 256-274.

Dziuban, C.D., Hartman, J.L., & Moskal, P.D. (2004). Blended learning. *EDUCAUSE Center for Applied Research Bulletin, 7,* 1-12.

Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre). (2007). *EPPI-Centre methods for conducting systematic reviews.* London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre). (2010). *EPPI-Centre methods for conducting systematic reviews.* London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education, 7*(2), 95–105.

Garrison, D., & Vaughan, N. D. (2008). *Blended learning in higher education: framework, principles, and guidelines.* John Wiley & Sons.

Gough, D. (2007). Weight of evidence: a framework for the appraisal of the quality and relevance of evidence. *Research papers in education, 22*(2), 213-228.

Gough, D., Oliver, S., & Thomas, J. (2012). *An introduction to systematic reviews*. Sage Publications.

Halverson, L. R., Graham, C. R., Spring, K. J., & Drysdale, J. S. (2012). An analysis of high impact scholarship and publication trends in blended learning. *Distance Education, 33*(3), 381-413.

Hirumi, A., Bradford, G., & Rutherford, L. (2011). Selecting delivery systems and media to facilitate blended learning: A systematic process based on skill level, content stability, cost and instructional strategy. *Journal of Online Learning and Teaching, 7*(4), 489-501.

Hofmann, J. (2006). Why Blended learning hasn't (yet) fulfilled its promises. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs* (pp. 27-40). USA: Pfeiffer Publishing.

Holden, J. T., & Westfall, P. J-L. (2010). *An instructional media selection guide for distance learning: Implications for blended learning and virtual worlds.* USA: United States Distance Learning Association.

Hossain, D., Kim, J. K., Lee, J. Y., & Kim, K. J. (2012). Impacts of cognitive media attributes and motivation on IPTV adoption: Exploring the moderating effects of agricultural information. *Information Development, 28*(4), 300–315.

Huang, M-H. (2003). Designing website attributes to induce experiential encounters. *Computers in Human Behavior, 19*, 425–442.

Jonas, P. (2012). Successfully teaching with humorous videos: Videagogy. *New Horizons for Learning, 10*(1). Retrieved from http://education.jhu.edu/PD/newhorizons/Journals/Winter2012/Jonas

Kay, R. H. (2012). Exploring the use of video podcasts in education: A comprehensive review of the literature. *Computers in Human Behavior, 28*(3), 820-831.

Kember, D., McNaught, C., Chong, F. C. Y., Lam, P., & Cheng, K. F. (2010). Understanding the ways in which design features of educational websites impact upon student learning outcomes in blended learning environments. *Computers & Education, 55*(3), 1183-1192.

Kerres, M., & De Witt, C. (2003). A didactical framework for the design of blended learning arrangements. *Journal of Educational Media, 28*, 101-113.

Kitchenham, B. (2004). *Procedures for Performing Systematic Reviews.* Joint Technical Report Software Engineering Group Department of Computer Science, Keele University Keele, Staffs ST5 5BG, UK

Kozma, R. B. (1994). The Influence of Media on Learning: The Debate Continues. *School Library Media Research SLMQ, 22*(4).

Lengel, R. H., & Daft, R. L. (1984). *An exploratory analysis of the relationship between media richness and managerial information processing*. Texas A and M university college station department of management. TX 7784.

Liu, Q., Peng, W., Zhang, F., Hu, R., Li, Y., & Yan, W. (2016). The effectiveness of blended learning in health professions: Systematic review and meta-analysis. *Journal of Medical Internet Research, 18*(1).

Mayer, R. E. (2001). *Multimedia learning.* UK: Cambridge University Press.

Mayer, R. E. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction, 13*(2), 125-139.

Mayer, R. E. (2014). Research-based principles for designing multimedia instruction. In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum*. Retrieved from the Society for the Teaching of Psychology website http://teachpsych.org/Resources/Documents/ebooks/asle2014.pdf

Mayer, R. E., & Moreno, R. (2002). Aids to computer-based multimedia learning. *Learning and Instruction, 12*(1), 107-119.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43-52.

McCutcheon, K., Lohan, M., Traynor, M., & Martin D. (2015). A systematic review evaluating the impact of online or blended learning vs. face-to-face learning of clinical skills in undergraduate nurse education. *Journal of Advanced Nursing, 71*(2), 255–270.

McElhaney, K. W., Chang, H. Y., Chiu, J. L., & Linn, M. C. (2015). Evidence for effective uses of dynamic visualisations in science curriculum materials. *Studies in Science Education, 51*(1), 49-85.

McFarlin, B. K. (2008). Hybrid lecture-online format increases student grades in an undergraduate exercise physiology course at a large urban university. *Advances in Physiology Education, 32,* 86-91.

McLaughin, A. C., Rogers, W. A., Sierra, E. A., & Fisk, A. D. (2007). The effects of instructional media: Identifying the task demand/ media match. *Learning, Media and Technology, 32*(4), 381-405.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies.* Technical Report. USA: US Department of Education.

Mishra, S. (2002). A design framework for online learning environments. *British Journal of Educational Technology*, *33*(4), 493-496.

Moore, J. L., Dickson-Deane, C., & Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same?. *The Internet and Higher Education*, *14*(2), 129-135.

Nowell, G. (2011). Student Course Evaluations in Traditional and Blended Courses: A Case Study. *American Journal of Business Education*, *4*(1), 13-18.

Nugraini, S. H., Choo, K. A., Hin, H. S., & Hoon, T. S. (2013). Impact of E-AV biology website for learning about renewable energy. *The Turkish Online Journal of Educational Technology*, *12*(2), 376-386.

Perry, E. H., & Pilati, M. L. (2011). Online learning. *New Directions for Teaching and Learning*, (128), 95-104.

Picciano, A. G. (2007). Introduction. In A. G. Picciano & C. D. Dzuiban. (Eds.), *Blended learning research perspectives* (pp. 5-18). USA: Sloan-C.

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. Cambridge University Press.

Repetto, J. B., & Spitler, C. J. (2014). Research on At-Risk Learners in K-12 Online Learning. In R. E. Ferdig, K. Kennedy (Eds.), *Handbook of Research on K-12 Online and Blended Learning* (pp. 107-134). Canada: ETC Press.

Rudd II, D. P., & Rudd, D. P. (2014). The value of video in online instruction. *Journal of Instructional Pedagogies*, *13*, 1.

Saettler, P. L. (2004). *The Evolution of American Educational Technology.* USA: Information Age Publishing.

Sahin, M. (2010). Blended learning in vocational education: An experimental study. *International Journal of Vocational and Technical Education, 2*(6), 95-101.

Tess, P. A. (2013). The role of social media in higher education classes (real and virtual) - A literature review. *Computers in Human Behavior*, *29*(5), A60-A68.

Van Merrienboer, J. G., Clark, R., & de Croock, M. B. M. (2002). Blueprints for complex learning. The 4C/ID-model. *Educational Technology Research and Development, 50*(2), 39-64.

Wallace, R. M. (2003). Online learning in higher education: A review of research on interactions among teachers and students. *Education, Communication & Information*, *3*(2), 241-280.

Wang, Y., Han, X., & Yang, J. (2015). Revisiting the Blended Learning Literature: Using a Complex Adaptive Systems Framework. *Educational Technology & Society*, *18*(2), 380-393.

Whitelock, D. & Jelfs, A. (2003) Editorial: Journal of educational media special issue on blended learning. *Journal of Educational Media*, *28*(2-3), 99-100.

Williams, C. (2002). Learning on-line: a review of recent literature in a rapidly expanding field. *Journal of Further and Higher Education*, *26*(3), 263–272.

Yang, K-T., Wang, T-H., Chiu, M-H. (2014). How technology fosters learning: Inspiration from the “Media Debate”. *Creative Education, 5*, 1086-1090.

Acknowledgments

We would like to acknowledge the assistance of graduate student in Educational Sciences, Ms. Sara Stojkovic, during the first systematic review study.

Appendices

Appendix A

List of databases and journals searched

Database/Journal	Study
ProQuest	SRS1 and 2
Scopus	SRS1 and 2
Web of Science	SRS2
American Journal of Distance Education	SRS1
Australian Journal of Educational Technology	SRS2
British Journal of Educational Technology	SRS1
Canadian Journal of Learning and Technology	SRS2
Computers and Education	SRS1 and 2
Computers in Human Behavior	SRS2
Distance Education	SRS1 and 2
Educational Technology Research and Development	SRS2
Electronic Journal of e-Learning	SRS1
Interdisciplinary Journal of E-learning and Learning Objects	SRS2
International Journal of E-learning and Distance Education	SRS2
International Journal of Mathematics Education in Science and Technology	SRS2
Journal of Computer Assisted Learning	SRS2
Journal of Computing in Higher Education	SRS1
Journal of Distance Education.	SRS1

Appendix B

SRS1 - Reviewed studies

Article	Study participants	Setting and location	Subject area	Media types compared	Assessment	Primary outcome
Cooper and Higgins (2015)	98 students, aged 17 and over; mixed sex	Higher education institution in the USA	**Phys. Ed.** Teaching the structure of the rehabilitation module: the structure of the rehabilitation continuum, exercise appropriate for each stage and progress criteria.	• **Video with narration** Videos of various length were compared, shorter videos averaging around 1.58 minutes, and longer videos 10.2.324 to 18.14 minutes in length.	**Type of outcome examined** • **Student performance** Longitudinal, blinded, crossover design. Study took place over 18 weeks divided into three 6-week periods within two consecutive academic years. At the end of each period, students were required to produce rehabilitation sessions in groups, and were assessed on five criteria encompassing cognitive, affective and psychomotor dimensions.	**Evidence of greater effectiveness of one condition over another?** • No The study found no statistically significant difference between the experimental groups ($F(2, 104) = 0.17$, $p = 0.85$). According to the magnitude-based inferences, both of the video groups were found to be "almost certainly not harmful" to the participants, and more specifically, that videos are to some degree beneficial when students are working in groups. A comparison of the two video groups demonstrated a substantially reduced mean difference and an insubstantial effect size (0.05), suggesting the different delivery durations, any infringement of the redundancy principle and the production value made little difference to the scores achieved by the groups.

Doo (2005)	86 students aged 17 and over; mixed sex	Higher education institution in the USA	**PSE** Interpersonal skills training: job interview skills - behaviour-based and verbal.	• **Text only** (Verbal information in written format without visuals) • **Static visual AND audio** (Auditory information plus still, realistic visuals) • **Video with narration** (Auditory plus visual information in full motion) • **Audio only** (Auditory information without visuals)	**Type of outcome examined** • **Student performance** A short-term online retention test with 14 multiple-choice items was used to assess how much participants recalled the concepts and principles presented. In addition, participants were assessed on verbal interview and behavior-based skills using an observation checklist. • **Student perceptions** • **Student satisfaction**	**Evidence of greater effectiveness of one condition over another?** • No The ANOVA result indicated that there was no significant difference between groups in neither the short-term cognitive retention of the learning content ($F(3, 82) = 0.75$, $p = 0.05$) nor in behavioural reproduction of behaviour-based ($F(3, 82) = 0.40$, $p = 0.05$) and verbal interview skills ($F(3, 82) = 0.54$, $p = 0.05$).
Griffin, Mitchell, and Thompson (2009)	90 students aged 17 and over; sex not specified	Higher education institution in the UK	**Science** Two topics unrelated to students' course of study: "Sleepwalking	• **Static visual AND audio** Two variations compared: 1. static visuals	**Type of outcome examined** • **Student performance** 10-question multiple-choice test (5 questions for each topic covered) • **Student perceptions**	**Evidence of greater effectiveness of one condition over another?** • Yes Synchronous presentation led to significantly higher scores ($p < 0.002$) than separate. At the most basic level of learning (knowledge)

			and other parasomnias" and "Hot air balloons and how they work"	synchronised with audio recording of lecture, 2. static visuals separate from audio recording	• **Student satisfaction**	the synchronous format gave significantly higher scores (p > 0.05), while in other categories of the cognitive process dimension there were no significant differences.
Heo and Han (2013)	114 students aged 21 and over; mixed sex	Higher education institution in South Korea	**Other curriculum** Counselling psychology	• **Text AND static visual(s)** • **Text AND video/animation** • **Video only** (Presence of subtitles and narration has not been specified.)	**Type of outcome examined** • **Student performance** 20 multiple choice questions • **Student satisfaction** instructional motivation	**Evidence of greater effectiveness of one condition over another?** • No Three types of instruction were not shown to have a different effect on students' comprehension of content according to a 3x2 factorial ANOVA ($F(2, 108) = 1.57$, $p = 0.213$, partial $\eta 2 = 0.028$), but the use of video does seem to promote motivation of online students ($F(2, 108) = 4.25$, $p < 0.05$, partial $\eta 2 = 0.073$).
Hilbelink (2009)	124 students aged 17 and over; sex not specified	Online higher education setting	**Science** Anatomy course: study of the skull, examination of identification and spatial relationships.	• **Static visual only** Comparing effectiveness of 3D stereo-imaging to 2D images.	**Type of outcome examined** • **Student performance** Practical examination on a) identification, and b) structures and relationships.	**Evidence of greater effectiveness of one condition over another?** • Yes A Doubly-MANOVA test showed the 3D stereo-image treatment group had significantly higher scores in learning the anatomy of the skull, both on measures of identification as well as relationship (Wilk's Lambda [0.0479, $p < 0.0001$]).

Ibrahim, Callaway, and Bell (2014)	156 students aged 17 and over; mixed sex	Online higher education setting	**ICT** The technological pedagogical content knowledge (TPACK) Conceptual framework.	• **Video with narration** Three videos were used: 1. video with segmentation (three short segments) AND signaling (highlighting and summarizing the main ideas before and after each segment) 2. video with segmentation, but without signalling 3.video in continuance, without segmentation or signaling	**Type of outcome examined** • **Student performance** 15-question pretest and 15-question multiple choice posttest (10-question retention and 5- question transfer) • **Student perceptions** 1-question instrument nine-level Likert scale to assess students' perceived difficulty of the module as an indirect subjective measure of cognitive load	**Evidence of greater effectiveness of one condition over another?** • Yes The ANCOVA analysis indicates a significant effect ($F(2, 138) = 3.811$, $p = 0.02$) of the TPACK video design on students' learning outcomes, indicating that segmentation and signaling accounted for a 5.2% improvement in students' learning outcome. Treatment condition which included segmentation and signaling as part of the video improved students' learning outcomes.
Kaplan and Wu (2006)	75 students aged 21 and over; mixed sex	Higher education institution in the USA	**Maths** Probability solving and design research: compound events,	• **Text only** • **Static visual only** • **Static visual with motion cues**	**Type of outcome examined** • **Student performance** Time on problems and students' notes were assessed in addition to	**Evidence of greater effectiveness of one condition over another?** • Yes Treatment groups provided with visuals solved more problems correctly. Animation groups equally

			mutually exclusive events, the addition rule for mutually exclusive events.	• **Animated visual** • **Interactive animated visual**	the solutions to two transfer problems: 1. static visual outcome graph 2. static visual outcome graph with increased problem difficulty	outperformed Text alone and Static Visual groups on training and transfer problems; the Motion Cues groups outperformed all other groups on transfer problems presented in a static visual format. The contrasts were significant at alpha 0.05. The number of images and movement symbols was shown to be a significant predictor of correct solutions on training problems (at alpha 0.01) and transfer problems (at alpha 0.001).
Kößler and Nitzschner (2015)	82 students aged 17 and over; mixed sex	Higher education institution in Austria	**Business Studies** Economics: opportunity costs	• **Text only** Text was taken from Wikipedia, in English (foreign language to participants); time needed to read the text same as length of video • **Video only** a) a funny video (a cartoon explaining the topic with the help of a character	**Type of outcome examined** • **Student performance** Six multiple choice questions requiring a transfer to an example not directly part of the presented material.	**Evidence of greater effectiveness of one condition over another?** • Yes ANCOVA results indicated significant differences between the humorous video and both the text (p = 0.1) and the serious video (p = 0.01). The text and the serious video did not differ from each other significantly (p = 0.67). In the humorous video condition significantly more items were answered correctly (M = 4.89, SD = 0.80) than in the serious video condition (M = 4.31, SD = 1.07) and

				searching for a mate) b) a serious video (an economic expert giving a talk on the topic)		the written text condition (M = 4.15, SD = 0.92)
Lin and Dwyer (2010)	582 students aged 17 and over; mixed sex	Higher education institution in the USA	**Science** Physiology: the human heart – its parts, locations, and functions during the diastolic and systolic phases.	• **Text AND static visual(s)** 3 treatment groups: - static visuals only – static visuals + questions - static visuals + questions + feedback • **Text AND video/animation** 3 treatment groups: - animated visuals only - animated visuals + questions - animated visuals + questions + feedback • **Static visual only**	**Type of outcome examined** • **Student performance** Four tests consisting of 20 multiple-choice items each: identification test, terminology test, comprehension test and a drawing test.	**Evidence of greater effectiveness of one condition over another?** • Yes The learners in the animated visual treatment condition significantly outperformed the learners in the static visual group in all four tests. After controlling for the time-on-task, however, animation was found to only have significant effect in facilitating achievement on the drawing test.

				• **Animated visual**		
Lin and Tseng (2012)	88 students aged 11-16; sex not specified	Primary school in China	**Literacy - further languages** English language vocabulary for non-native learners.	• **Text only** • **Text AND static visual(s)** • **Text AND video/animation**	**Type of outcome examined** • **Student performance** Posttest consisting of 10 questions of production and 10 questions of recognition, administered immediately after reading the passage and again two weeks after the treatment.	**Evidence of greater effectiveness of one condition over another?** • Yes In both posttests the video condition group scored significantly higher than the text group and the picture group, both on recognition and production tests ($p < 0.05$). The findings indicate that learning difficult words with textual definitions and videos is more effective than learning them with textual definitions and pictures, and with textual definitions alone.
Sung & Mayer (2012)	200 students aged 17 and over; mixed sex	Higher education institution in South Korea	**Other curriculum** History and definition of distance education	• **Text only** • **Text AND static visual(s)** Three variations: 1. containing instructive graphics, 2. seductive graphics and 3. decorative graphics	**Type of outcome examined** • **Student performance** Pretest and recall test about key concepts. • **Student satisfaction**	**Evidence of greater effectiveness of one condition over another?** • Yes The instructive graphics group significantly outperformed each of the other three groups (at $p < 0.05$), which did not differ significantly from each other. Instructive graphics outperformed the other three groups, which did not

						significantly differ from each other in terms of learning outcomes.
Yadav et al. (2011)	30 students aged 17 and over; mixed sex	Higher education institution in the USA	**Science** Biology: personal narratives about HIV/AIDS	**• Text only** **• Text AND video/animation** Video embedded on a webpage containing text **• Video only**	**Type of outcome examined** • **Student performance** 6-week recall interview • **Student perceptions**	**Evidence of greater effectiveness of one condition over another?** • No The mediums did not differ in terms of their influence on cognitive factors. Specifically, the verbal protocol analysis exhibited no difference on participants' cognitive processing and cognitive dissonance. Also, the recall differences between the mediums were not found to be significant.
Zhang, Zhou, Briggs, and Nunamaker (2006)	138 students aged 17 and over; mixed sex	Higher education institution in the USA	**ICT** Internet technology: Search engines and Information retrieval	**• Text AND static visual(s)** **• Video only** Two variations were compared: 1. Interactive (segmented) video, 2. non-interactive video	**Type of outcome examined** • **Student performance** Pre-test with true-false and multiple-choice questions; post-test with objective questions with standard answers about the lecture content • **Student perceptions** • **Student satisfaction**	**Evidence of greater effectiveness of one condition over another?** • Yes Post-gain of group using interactive video was significantly higher than that of the other groups ($p < 0.005$ compared to group with linear video, $p < 0.001$ to group with static visuals and text). No statistically significant difference between group with noninteractive video and group without any video.

Appendix C

SRS2 - Reviewed studies

Article	Study participants	Setting and location	Subject area	Media types compared	Media attributes	Learning environment	Assessment	Primary outcome
Baturay and Bay (2010)	78 students; mixed sex; age not stated	A higher education institution in Turkey	**ICT** Introduction to computers	**Online tutorial AND problem-based learning guidance** with discussion boards **Online tutorial**	Interactivity, synchronicity and asynchrony	Online learning environment	**Student performance:** pre and post-tests, achievement tests, assignments; **Self-efficacy; Classroom community**	**Evidence of greater effectiveness of one condition over another?** Yes In the pre and post-tests the intervention group scored significantly higher than the control group. The control group had significantly higher assignment grades than the intervention group. Midterm and final exam scores was not significant in both groups.
Craig and Freihs (2013)	154 students; age and sex not stated	A university in the USA	**Social science** Library instruction: BIOSIS Previews	**Video Text (HTML)**	Interactivity and navigability	Blended learning environment	**Student performance:** 5 quiz questions; **Student confidence**; **Self-efficacy**	**Evidence of greater effectiveness of one condition over another?** Yes Students in the video section score higher than students in the text (HTML) section. The scores of questions 1, 2, and 5 was statistically significant different ($p < .05$).

Curran, Fleet and Kirby (2010)	153 Physicians and Postgraduate residents; mixed sex; age not stated	A university in Canada	**Science** Medicine: Emergency medicine and Trauma cases	**Scheduled group learning format** with case-based asynchronous discussion boards and online tutorials **eCME on Demand format** with asynchronous discussion boards	Interactivity, flexibility and asynchrony	Online learning environment	**Student performance**: pre and post-assessment comprised of 5 multiple choice questions; **Student satisfaction; Student confidence**	**Evidence of greater effectiveness of one condition over another?** Yes Participants in the SGL format performed significantly higher on both pre and post-knowledge assessment than participants in the On Demand format. A paired samples t-test analyses indicated a significant pre to post-knowledge increase ($p = .000$) for both course formats at the $p < .05$ probability level.
Evans and Cordova (2015)	115 students; mean age: video group - 22.04, non-video group - 22.74; gender	A Higher Education institution in the USA	**Social science** Political Science: Introduction to American Government	**Non-video** (PowerPoint slides and lecture notes) **Video** (lecture videos 30 minutes)	Media richness and flexibility	Online learning environment	**Student performance:** 4 exams; **Student satisfaction**	**Evidence of greater effectiveness of one condition over another?** Yes On the first exam students in both sections performed equally. But, on the next three exams, the students in the video course outperformed the students in the non-video course. Using a difference-of-means t test, difference between the two sections was significant at

	not stated							the $p \leq .10$ level for the second exam. Averagely, students in the video course scored higher on three of the four exams.
Garcia-Cabot et al. (2015)	30 graduate students; sex and age not stated	A university, location not stated	**ICT** Web engineering: Human-computer interaction	**m-learning adaptive tool e-learning**	Ease of use, interactivity, flexibility, individualization (personalization) and mobility	Blended learning environment	**Student performance:** mid-term assignment (30%), final assignment (50%) and examination (20%); **Student attitude**	**Evidence of greater effectiveness of one condition over another?** Yes The experimental group has statistically significant higher overall score than the control group. In the mid-term assignment experimental group students outperformed students in the control group but there was no significant difference. No differences were observed in the examination score.
Han (2013)	33 graduate students; mixed sex; mean age: 40	A university in the USA	**Education** History of Educational Policy	**Video casting** Elluminate live: text chat, voice chat on the microphone and whiteboard presentation, conveying non-verbal	Interactivity, synchronicity, proximity (instructor's nonverbal cues) and media richness	Online learning environment	**Student performance:** midterm and final term assignment; **Student satisfaction; Social presence scale**	**Evidence of greater effectiveness of one condition over another?** Yes No significant difference in the midterm grades. However, the experiment group had higher grades than the control group in the final assignment.

				and social cues. **Audio**				
Hegeman (2015)	95 students; mixed sex; mean age: 1st group - 23.47, 2nd group - 26.09	A university in the USA	**Maths** College Algebra	**Instructor-generated video** **Text-based multimedia** (Publisher-generate or instructor-generated)	Interactivity, responsiveness, individualization, flexibility and proximity (instructor's teaching presence)	Online learning environment	**Student performance**: Online Homework (10%), Online Quizzes (10%), Online Exams (30%), Handwritten Midterm Exam (25%), Handwritten Common Comprehensive Final Exam (25%). (Online Homework 5% and Class Participation 5% only in the	**Evidence of greater effectiveness of one condition over another?** Yes In the online homework the control group scored higher than the experimental group, though no statistically significant difference both groups p=0.613. In online quiz, online exam, handwritten midterm exam and handwritten final exam: the overall scores were statistically significantly higher in the experimental group than the control group, p=0.035, 0.002, 0.001, 0.007 respectively.

							redesigned online course); **Time on task; Course grade distribution and student attrition; Teacher presence as a predictor of student success**	
McGovern and Baruca (2013)	182 students; mixed sex; age not stated	A private university in the USA	**Business studies** Marketing: Distribution and Marketing using social media	**Personalized video F2F class AND personalized video F2F class AND non-personalized video** 14 minutes video in all groups	Individualization (personalization)	OBLEs	**Student performance:** 10-question quiz; **Student perceptions**	**Evidence of greater effectiveness of one condition over another?** Yes The one-way ANOVA result indicated a significant differences at the $p < .05$ level. For the three Groups: $F(1, 182) = 38.992$, $p < .001$. The effect size $\eta 2$ was .31. Post hoc comparison using the Tukey HSD test indicated that the mean score of Group 1 ($M = 9.16$, $SD = 1.29$) was higher than the mean score of Group 2 ($M = 8.21$, $SD = 1.92$), and the mean score of

								Group 2 was higher than the mean score of and Group 3 (M = 6.18, SD = 2.21).
Ridgway et al. (2007)	88 medical students; sex and age not stated	A university in Ireland	**Science** Medicine: Surgery lectures	**Aural group:** text AND graphics AND voice-over **Non-aural group:** text AND graphics	Interactivity, ease of use and media richness	Online learning environment	**Student performance:** 100 Multiple-choice questionnaire (MCQ); **Student usage rates; Students perceptions**	**Evidence of greater effectiveness of one condition over another?** Yes Median MCQ marks were significantly higher in the aural group than the non-aural group, p = 0.012, Kruskal–Wallis test.
Sahasrabudhe and Kanungo (2014)	70 graduate students; mixed sex mean age: 29.89;	A university (3 campuses) in the USA	**Business studies** 2 topics: General Linear Models (GLM) and Logistic Regression (LR)	**Text AND graphics (TG)** **Text AND graphics AND sound (TGS)** **Text AND graphics AND talking-head (TGTH)**	Media richness	Blended learning environment	**Student performance:** Comparative group Post-test-only; **Student perceptions**	**Evidence of greater effectiveness of one condition over another?** Yes 1st topic: student learning effectiveness increase up to TGS and no further increase for TGVA. p-value 0.0002, partial eta square= 0.241. In the 2nd topic, student learning effectiveness increase up to TGTH and no further increase for TGVA

				Text AND graphics AND video/animation **1st topic:** TG, TGS (40 minutes) and TGVA (43 minutes), **2nd topic:** TGS, TGTH (40 minutes) and TGVA (43 minutes)				p-value 0.0004, partial eta square= 0.267.
Vural (2013)	318 students; mixed sex; age not stated	A university in Turkey	**ICT** Computer literacy course	**Question-embedded interactive video** **Interactive video**	Interactivity, flexibility and media richness	Online learning environment	**Student performance:** 2 quizzes - 1st quiz based on a content of the same interactive online video, 2nd quiz was conducted after the treatment	**Evidence of greater effectiveness of one condition over another?** Yes The ANCOVA results F(1, 314) = 4,615, p = .032, p < .05, indicated that the students who took the QVE tool significantly performed better than the students who took the IVE tool. The effect size η2 (partial eta squared) = 0,014.