25 principles for effective instructional video design

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This paper reports on the first phase of a broader study into effective design of instructional video. While instructional videos are increasingly popular as learning objects, increasingly easy to create by any educator, and have been shown to support effective learning as well as being scalable and re-usable, there is a lack of clarity about what educators need to consider when creating or choosing them. Instructional videos differ from other film media in that they are primarily intended to teach content, concepts, or skills. Building on Mayer's (2014) work in which 15 instructional design principles were identified for multimedia learning, this paper presents 25 principles emerging from a broad-based exploratory literature review specifically focused on instructional video design.

Keywords: Instructional videos, cognitive theory of multimedia learning, instructional design.

Introduction

The use of instructional videos is increasingly common in higher education. Instructional videos are designed to teach specific content, skills or concepts, and differ from other educational videos such as narrative films, or those designed primarily to facilitate communication or collaboration. A growing body of literature affirms that instructional video is not only popular with students (Henderson, Selwyn, & Aston, 2015), but can also enhance student learning. For example, videos can facilitate learning by giving students control over the pace of instruction (Murray, Koziniec & McGill, 2015). An emerging advantage is that videos are also easily trackable for learning analytics (Kim, et al., 2014). In comparison with traditional texts such as static readings or diagrams, effectively designed videos have been found to facilitate greater learning (Castro-Alonso et al., 2019; Hoffler & Leutner, 2007) and increased motivation (Abeysekera & Dawson, 2014). Importantly, instructional videos are also believed to be advantageous because they are scalable, enduring, and re-usable. Scalability is an increasingly important factor in the context of increasingly massified classes. Such videos are also enduring and re-usable, allowing them to persist over time for re-use by students within a class, and re-use by educators for different classes or cohorts.

Given such advantages, it is understandable that universities are embracing the affordances of instructional videos. While videos created at universities previously consisted largely of lecture capture, many universities and other institutions of higher learning now create more deliberately produced content (see Chorianopoulos, 2018 for a taxonomy of video styles). These can be expensive, with Hollands and Tirthali (2015) estimating that a single hour of high quality, finished MOOC video can cost $US4300 to produce. Even videos made by individual educators using low budget tools cost time and take educators away from other activities. Unfortunately, this time and expense does not guarantee that the videos are efficient at teaching students the desired content, concept, or skill as many simply transfer questionable teaching methodologies from the lecture hall to the screen (Guo, et al., 2014; Ibrahim et al., 2012).

When students feel university produced videos do not adequately meet their needs, they often look for substitutes, particularly on YouTube (Henderson et al., 2015; Shoufan, 2018; Tan & Pearce, 2011). Unfortunately, students are not always in possession of the kind of syntactical subject knowledge to determine whether a video is a reliable substitute. As such, they can find themselves lost in a "vast wasteland of garbage and social parody that adds nothing to the learning process" (Jones & Cuthrell, 2011, p. 81), in which some content analyses have found as low as 4% of videos on a given topic considered highly accurate (Al-busaidi, Anderson, & Alamri, 2017). This is personified by an unfortunate sociology student in Tan and Pearce's (2011) study who was sure she'd found a good explainer video on feminism, only to be told it was in fact a parody produced by a US right wing extremist group. As such, for both economic and academic reasons, it is incumbent on universities and academics who produce instructional videos to do it well.

Cognitive Theory of Multimedia Learning and Cognitive Load Theory.

The design of instructional videos should take into account how humans process information, or "the effectiveness of instructional design is likely to be random" (Paas & Sweller, 2014, p. 27). Cognitive Theory of Multimedia Learning (CTML), which is based on Cognitive Load Theory (CLT) presents theoretical propositions and

experimental data that aim to guide the process of multimedia design from the perspective of how the learner processes novel information. CTML is based on the premise that humans have a limited capacity to process new information, and that learning involves consciously organising this information into long term memory, which is effectively limitless (Ayers, 2015). By limiting extraneous processing imposed by poor instructional design, cognitive overload is avoided. This in turn allows cognitive processing to be allocated to the task of generating long term conceptual change, or schemas, which can also be encouraged through purposeful design (Muller et al., 2008). For a fuller explanation as to how each theory conceptualises human cognitive architecture, see Sweller, Ayers, and Kalyuga (2011) for CLT and Mayer (2014) for CTML. The two theories, while offering slightly different conceptions of human cognitive architecture, commonly agree on recommendations for instructional design. These principles of design have been shown to decrease extraneous cognitive load and therefore contribute to a more efficient learning experience, specifically for low proficiency learners (De Jong, 2010). Conversely, "poorly constructed materials" (Ayres, 2015, p. 632) that don't take into account cognitive load tend to lead to inferior learning outcomes in experimental conditions. It is possible, therefore, as Mayer (2014) has done, to synthesise the experimental literature from the two fields into a single set of instructional design recommendations.

Methodology

This paper reports on the first phase of a broader study on the effectiveness of instructional video. In this phase a three stage literature review was conducted with the aim of providing the investigators with a synthesis of the research literature relating to the design of effective instructional video. An outcome of this process was the finding that there is considerable variation in what is understood to be effective design principles, as well as surprising silences in the literature, especially with respects to contextual and affective influences.

The principles in Table 1 emerged from a three stage literature review focused on effective design of instructional videos. Stage 1 involved searches of ERIC, ProQuest, and Google Scholar. Results were limited to peer reviewed journals, peer reviewed conference papers, and book chapters. The search terms combined each of Mayer's (2014) 15 principles of multimedia instructional design with the terms animation or video. Due to the emerging nature of educational video design research, a second stage involved a broad-based exploratory search for papers investigating MOOC, YouTube and instructional video efficacy or design. Stage three consisted of a snowballing technique utilising the reference lists of the selected works. Sources were then excluded from the pool if they were not empirically based or if their analysis and findings did not specifically address design recommendations of instructional videos. Sources included experimental studies or meta-analyses of experimental studies, as well as descriptive case studies. The inclusion of qualitative studies is a deliberate break from the tradition of CTML/CLT, which preferences experimental designs (Mayer, 2014). Such studies, embedded in real world settings, are valuable in revealing considerations relating to the role of context and affect on the design and use of instructional videos. This review does not try to establish any comparative value between the principles, but rather to first identify what principles are relevant in instructional video design and as such, the inclusion of a range of study designs is deemed appropriate.

In total, 66 papers or chapters were then reviewed for explicit and empirically justified statements or principles regarding the design of effective instructional video. These statements were extracted and a theoretical thematic analysis was conducted similar to the process described by Braun and Clarke (2006). As such, an initial coding structure was based on Multimedia Learning Theory and in particular Mayer's (2014) three categories and 15 principles of multimedia design. However, in recognition of the exploratory nature of this literature review, a constant comparative method was also adopted: when an extract did not fit with an existing code, a new code or category was created until all of the data had been incorporated and theoretical saturation had been achieved. These codes were then thematically analysed and resulted in 25 principles organised according to Mayer's three categories, plus one additional category for interface design.

A complicating factor in developing this summary table was that the fields of CLT and CTML use different nomenclature for very similar concepts and principles, including the three kinds of cognitive processing that constitute the principle categories. As such, some principles on this list retain Mayer's (2014) CTML titles, some are given their CLT titles, some are split or combined to better describe the variety of design considerations contained within a single principle, and new principles emerging from the literature have been named. Decisions on the title chosen for each principle were guided by the dominant title in the literature or when such a title did not emerge, the authors' perception as to the most intuitive descriptor for each.

25 Principles of instructional video design

The first group of principles presented in Table 1 (audio quality, coherence, seductive detail, split attention, attention guiding, redundancy, worked examples, and animation type) are designed to minimise extraneous cognitive processing by reducing unnecessary distractions. The second group (modality, transient information, and optimal video length) help to manage intrinsic or essential processing, aiming to make learning the content as easy as possible. The third group (personalisation, emotional design, encouraging mental model making, misconceptions, and pre-training) encourage germane or generative processing, which aims to encourage students to connect novel information to existing schemas. In addition to Mayer's (2014) three categories, a fourth category ("Interface Design Principles") was derived from the data which included three principles regarding the interface used to display instructional videos in education (learner control, segmentation, and integrated activities). Table 1 lists the name and description of the principles, however, due to space constraints in this short paper, only one example source is cited for each principle [email the authors for the full table].

Table 1: Summary of CLT/CTML video design principles

Principle	Design advice	Example of literature
Extraneous Load Minimisation Principles		
Audio Quality	Audio should be clear, with no distracting hissing or interference	Kuhl et al. (2014)
Coherence	Only instructional material directly related to the key learning goal should be included.	Mayer & Fiorella (2014)
Seductive Detail (music)	Avoid including background music	Moreno & Mayer (2000)
Seductive Detail (visual distraction)	Avoid including interesting but unnecessary material in the name of entertainment or advertising	Park, Korbasch & Brunken (2015)
Split Attention (Temporal)	Related elements (such as narration and visuals) should be presented at the same time	Mayer & Fiorella (2014)
Split Attention (Spatial)	Related elements (animations and words) should be presented in close physical proximity on the screen	Schroeder & Cenkci (2018)
Split Attention (Competing Sources)	Visuals and narration sources should describe one learning focus at a time.	Ayers & Sweller, 2014
Attention Guiding Principle	Learners should have important information deliberately pointed out or selectively revealed during presentation. Use of arrows, highlighting, flashing etc.	Xie, Wang, Zhou, & Wu (2016)
Redundancy Effect	On screen text longer than four words should not be read out loud.	Mayer & Fiorella (2014)
Worked Example Effect	Videos should include full worked examples of the skill or concept, not force learners to generate answers through problem solving. (NA for content only videos)	Chen, Kalyuga, & Sweller (2015)
Animation Type	Style of animation should be guided by content, with conceptual learning best taught through animation and procedural 'how to' instruction taught through first person live capture. Must avoid simple decoration	Hoffler & Leutner (2007)
Intrinsic/Essential Load Management Principles		
Modality	Learning is enhanced when pictures are accompanied by simultaneous narration	Ginns (2005)
Transient Information Effect	Narration sections should be kept short and uncomplicated.	Leahy and Sweller (2015)
Optimal Video Length	Videos designed for secondary school students should not run longer than five minutes, and tertiary students six minutes. Longer videos should be edited or split.	Ibrahim, Antonenko, Greenwood, & Wheeler (2012)
Germane/Generative Processing Principles		
Personalisation (Human Voice)	Narrations should be recorded in a human voice rather than synthesised, machine voice.	Clark & Mayer (2016)
Personalisation (Conversational Voice)	Narrations should use first/second person conversational speech. Replacing "the" with "you or your" is effective.	Van der Meij (2017)

Personalisation (On screen agent)	On screen animated characters should exhibit 'human-like' gesturing rather than static, lifeless animation.	Mayer (2014)
Personalisation (Presenter's face)	Presenter's face should not be shown while complex visuals are being narrated. Otherwise, the practice is contested.	Van Gog & Rummel, (2010)
Emotional Design	Warm, high saturation colours should be used in videos.	Um, Plass, Hayward & Homer (2012)
Encouraging Mental Model Making	Videos should explicitly encourage learners to create mental models by prompting pausing of the video, contemplation statements, encouraging creative note-taking, and linking to previous learning.	Renkl (2014)
Misconception Effect	Conceptual videos should dispel common misconceptions at the start. Simple statements like "you might have thought…"	Muller, Bewes, Sharma, & Reimann (2008)
Pre-training principle	Key elements required to understand a concept should be taught to novice learners prior to watching the video, either by a tutor or in a preliminary video.	Mayer & Pilegard (2014)
Interface Design Principles		
Learner Control Effect	Video interface should be designed so that pause, play, speed up and slow down buttons are controlled by and clearly visible to the learner.	Kuhl, Eitel, Damnik & Korndle (2014)
Segmentation	The interface should be designed to pause after important information, prompting the learner to click 'continue'.	Mayer & Pilegard (2014)
Integrated Practice Activities	Designers should integrate practice activities, either during pauses in the presentation or following the video.	Szpunar, Jing & Schacter (2014)

Limitations and future research

Of the 66 papers and book chapters contributing to the principles in this research 55 were developed in experimental settings, which necessarily divorce the learning phenomenon from its real life context in teaching and learning environments. In education, context is central to pedagogical and technological decisions (Rosenberg & Koehler, 2015). As others have argued (see Winslett, 2014), more research needs to be undertaken to consider the impact context has on these principles and the impact of affective considerations on students' willingness to process information. Quite simply, the most 'cognitively effective' instructional video is useless if no educator selects it or no student is willing to learn from it.

Like previous approaches to rating instructional videos based on CLT/CTML principles (see Lucas & Abd Rahim, 2017) Table 1 appears to weight each design principle equally. The reality is, however, that reported effect sizes in the experimental literature vary wildly from audio quality at d=1.95 (Kuhl et al., 2014) to personalisation of on-screen agents at d=0.36 (Mayer, 2014). This suggests that time and money spent improving poor audio, such as by purchasing a quality microphone, is a more prescient investment than hiring an animator to improve on screen character movements. The ongoing systematic literature review is taking this into consideration and aims to establish a hierarchy of principles to triage design decisions. However, it is logical that there is a need for research into any moderating effect these design principles have on each other. Learner control, for instance, may reduce the impact of transient information.

Conclusion

This paper reports on an ongoing synthesis of literature to identify design principles that are specifically relevant for effective instructional videos. Instructional videos are an important, impactful and increasingly common instructional device. The 25 design principles described in this paper will assist educators in the difficult task of evaluating the instructional design of videos they are considering for use in pedagogical contexts, either during production, or when curating existing educational videos. The authors acknowledge that there are other important considerations that educators rightfully take into account when selecting instructional materials (factual accuracy, affect, student characteristics and interests etc.) and that this table and the research behind it is limited to the cognitive efficiency of design. Nevertheless, we argue that the 25 principles presented here represent a valuable starting point to promote purposeful cognitive design of instructional videos.

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