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Why and when does instructional video facilitate learning? A commentary to the special issue "developments and trends in learning with instructional video"

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ABSTRACT

Our commentary explores the questions of why and when does instructional video facilitate learning in the light of the findings reported in this special issue and previous literature. Three levels of explanation will be offered, according to the representational approach, the cognitive approach and the instructional approach. We then discuss some issues and directions for future research on learning from instructional video.

1. Introduction

The last decade has witnessed a tremendous expansion of the use of video for instructional purposes in both formal and informal educational contexts. Most universities propose as a standard service the recording and distribution of lectures primarily aimed at students who cannot attend classes because of professional or family duties, and also as a support for revision. In 2012, universities developed a considerable (and overrated?) enthusiasm for Massive Open Online Courses (MOOCs) in which video plays an important role to introduce content and exercises provided to participants in additional documents. In addition to these recent examples that have made video a popular research topic once again, far more ancient uses still prevail in some contexts, like educational documentaries for topics that cannot be easily demonstrated directly or practice-based video, demonstrating practice in context. The use of video in informal contexts is congruent to the success of video streaming websites like YouTube. As the development of technology in the last 15 years has made it possible to easily record, edit, and distribute video documents through the internet, a whole range of new formats have emerged together with new professions (e.g., youtubers) and business models. A part of this massive amount of video is made with intentional instructional purposes, whether it be the scientific explanation of a phenomenon, demonstration of a product or an expert procedure (the so-called tutorials), analysis of movies or video games, to cite a few examples. Interestingly, most internet video producers are not professionally trained in the domain of video production and develop their skills over time thanks mostly to viewers' comments (for those who reach an audience). As this brief listing demonstrates, formal and informal settings differ in the "nature" of video they use, yet they tend to be more and more alike, with universities seeking to follow the trends in order to be attractive to the younger generation.

The omni-presence of these various types of instructional video has raised a regained interest in research, as demonstrated by the present special issue. However, the diversity of formats, purposes and contexts makes it difficult for the research to cumulate findings. The instructional use of media and technology has been concomitant to the evolution of the technology itself: computational capacity of personal computers, graphics processing, networking through the internet. To a lesser extent, it has been accompanied – and not only preceded - by changes in instructional and conceptual theory (Molenda, 2008). Interestingly, videos have been extensively studied in the 1970s and 1980s, and they have remained to date a topic of interest in certain communities, like vocational training and professional development (e.g., Wetzel, Radtke, & Stern, 1994) but were supplanted in the 2000s by computer generated graphics – animation, virtual reality, simulation. As mentioned earlier, video has made a great come-back in education in the context of an extensive development of video streaming web services and the popularity, particularly amongst younger generations, of the "do it yourself" approach (Morain & Swarts, 2012). In the 2000s, the literature on multimedia learning has questioned the "added-value" of computer animation for learning (Ainsworth, 2008; Hegarty, Kriz, & Kate, 2003; Lowe & Boucheix, 2008; Tversky, Bauer-Morrison, & Bétrancourt, 2002), shifting the question from "does animation enhance learning?" to "*when* and *why* does animation enhance

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learning?". The why question is related to the conceptual models that identify the mechanisms underlying the supposed beneficial effect of video for learning. The when question deals with the design factors, either internal to the document like interactivity (Biard, Cojean, & Jamet, this issue), segmentation (Merkt, Ballmann, Felfeli, & Schwan, this issue), camera view point (Boucheix, Gauthier, Fontaine, & Jaffeux, this issue), gender or presence of the instructor (Hoogerheide, van Wermeskerken, van Nassau, & van Gog, this issue; van Wermeskerken, Ravensbergen, & van Gog, this issue), or external instructional design factors, here represented by van der Meij, Rensink, and van der Meij (this issue), with the inclusion of practice during instruction. An additional question is *for whom* dynamic visualizations are more effective (Höffler & Leutner, 2007), in this issue represented by Wong, Castro-Alonso, Ayres, and Paas (this issue), who conducted secondary analyses on data from three experiments, considering participants' visuospatial abilities and gender. The other papers considered participants' characteristics for control or complementary analysis, like Merkt et al. with working memory capacity and Hoogerheide et al. with gender.

Our commentary proposes to explore the why and when questions as defined above in the light of the findings reported in this special issue and previous literature. These questions have been raised in the multimedia learning literature repeatedly as new informational formats became available, in the 1970s for pictures vs. text, in the 1990s for animated vs. static visualizations and recently (again) for video-based material. In this commentary, we will distinguish three perspectives from which the literature has explained the effect of learning: the representational approach, the cognitive and perceptual approach, and the instructional approach. The commentary concludes with some issues and directions for future research on learning from instructional video.

2. Representational approach

The representational approach, more rarely adopted in the multimedia literature for learning than the cognitive perspective, consists of identifying the semiotic and communicational properties of video compared to other types of representational formats, that could be static visualizations or other types of dynamic visualizations like computer-generated animation.

In the same line, Plötzner and Lowe (2012) describe the "presentation dimension" in their framework for characterizing expository animations, with six sub-dimensions such as type of representation and spatio-temporal arrangements. In all papers in this special issue, the material used involved dynamic visualizations defined as depictions that change continuously over time and represent a continuous flow of motion, whereas static visualizations display only specific states of this flow (Kühl, Scheiter, Gerjets, & Gemballa, 2011; Schnotz & Lowe, 2008). The meta-analyses conducted of studies comparing dynamic vs. static visualizations reports an overall beneficial effect of using dynamic visualizations which appears stronger for procedural than for conceptual learning content (Höffler & Leutner, 2007) and is significantly influenced by diverse types of moderators like design factors (Berney & Bétrancourt, 2016) and participants' visuo-spatial abilities (Höffler, 2010). In this special issue, all contributions assume that video will help learning, provided that their design is in alignment with cognitive demands or task requirements, as will be examined in the section related to the cognitive perspective. Only Wong et al. (this issue) report a comparison between static and dynamic formats in interaction with gender.

A subtler distinction is in the type of dynamic visualization: pure video, screen capture or computer-generated graphics. Most papers used videos that were deliberate recordings of visual scenes that were then edited and delivered to the learners in order to convey content to be learned and information to be recalled, so as to solve similar and transfer problems or perform similar or transfer procedural tasks. In Merkt et al. (this issue), the material was not pure video but included computer-generated graphics. In van de Meij, Rensik, and van der Meij (this issue), the video was not the recording of scenes in the physical world but screen captures of software operations. According to Lowe and Boucheix (2008), the material device from which the visualization originates is less important than the type of change represented, described by Lowe (2004, p. 259) as form change (transformation), position change (translation) or inclusion change (transition). Then the beneficial effect of dynamic visualization is the result of the alignment between the perceptual properties of the visualization and the cognitive requirements for memorizing the content and performing the subsequent tasks. This is the perspective adopted in Boucheix et al. (this issue), who explain the effect of different camera viewpoints due to "the spatiotemporal alignment of perceptual salience with conceptual relevance to task requirement".

Nevertheless, the claim that the type of dynamic visualization does not matter is probably excessive. In her framework, Ainsworth (2008) presents different levels of explanation that account for the beneficial effect of animation, including motivational and effective explanations. Videos are said to be particularly engaging for learners for different reasons such as authenticity, contextualization, or personal addressing (Schwartz & Hartmann, 2007; cited by Derry, Sherin, & Sherin, 2014). One perfect illustration of authenticity is the BBC Two video demonstrating the fall of a feather and a bowling ball in a vacuum chamber. Though every post-secondary educated person is supposed to know what is going to happen, the video of the live demonstration is amazing, even for the NASA engineers who operate the chamber.

To the best of our knowledge, no research has considered the effect of video compared to computer generated graphics on subjective and objective learning outcomes but it may be interesting, in line with emotional design trend (e.g., Mayer, 2014), to investigate the relationship between affective reactions and learning processes in multimedia learning.

3. Cognitive and perceptual approach

The cognitive perspective is probably the most represented in the multimedia literature due to the prevalent theories in the domain (Cognitive Theory of Multimedia Learning - CTML, Mayer, 2005; Integrative Text and Picture Comprehension – ITPC, Schnotz, 2014). A large body of research in this perspective stems from the Cognitive load theory which posits that due to the limited capacity of working memory, learning can occur only if enough cognitive resources can be allocated to the germane processes of learning, i.e. to the construction of a mental representation of the content to be learnt. As early reviews highlighted (Bétrancourt & Tversky, 2000; Tversky et al., 2002), dynamic visualizations are transient, they deliver a continuous flow of information that impose a high perceptual and cognitive load. In addition, the learners should focus their attention on the most conceptually relevant changes, that are sometimes not the most perceptually salient (Lowe & Boucheix, 2008). Therefore, this line of research has particularly investigated the effect of design factors that could help learners to allocate their cognitive resources to the most relevant aspects of the learning material (like cueing and user control) in order to provide recommendations for designers (e.g., Mayer, 2014).

A second important issue is the cognitive and perceptual affordances of dynamic visualizations for learning. Tversky et al. (2002) mentioned that computer animations were particularly suitable to conveying contents that involve change over time since animations directly depict change over time whereas they have to be inferred from static frames. Consequently, provided that delivery features help learners to manage cognitive resources, the use of dynamic visualizations should be more effective than static visualizations for learning content that involves change over time (such as dynamic systems in biology, meteorology, and mechanics). Ainsworth (2008) offered the level of expressivity of the representation defined as "how the inherent properties of a representation affect the degree of computation required to make inferences from it" as a possible explanation. However, this claim assumes that the mental representation of dynamic content is continuous in itself or at least, that a continuous visualization is the best way to support the understanding of dynamic content. However, many studies particularly in the line of the event segmentation theory, which proposes that people conceive activities as sequences of discrete events organized hierarchically (Zacks, Tversky, & Iyer, 2001; Zacks et al., 2007). In the special issue, Biard et al. (this issue) and Merkt et al. (this issue) both investigated the effect of segmentation and pauses in order to help the learners in elaborating a hierarchical structure of the content. The findings were slightly in favor of segmentation in certain conditions, but both studies emphasized its imbrication with other factors, i.e. interactivity for Biard et al. and working memory capacity for Merkt et al..

An important issue that may be underestimated in the literature, is the nature of the learning content at stake. Whereas computer animation mostly represents conceptual models of dynamic phenomena (Bétrancourt, 2018), video is mostly used to convey procedural content, and particularly sensori-motor procedures. In this special issue, three studies used video demonstrating sensori-motor procedures (Biard et al., this issue; Boucheix et al., this issue; Wong et al., this issue); Two involved video of instructors demonstrating conceptual procedures (Hoogerheide et al., this issue; van Wermeskerken et al., this issue); Van der Meij et al. (this issue) used a video (screen capture) demonstrating software procedures and finally Merkt et al. (this issue) mixed conceptual and procedural explanations. The theories underlying the benefit of video for procedural learning (e.g., observational learning, mirror neurons, automatization to name a few) are very different to the ones underlying conceptual learning, based on the construction of a mental representation as highlighted in the CTML and ITPC models aforementioned. Though it would be beyond the scope (and length!) of this commentary to get into deeper theoretical considerations, we believe that the research should pay much attention to the type of learning content or in other words what is to be learned from the video and how the very nature of video supports the learning processes and outcomes.

4. Instructional approach

As mentioned in the introduction, the use of video in instructional situations dates back to the 1970s with educational TV broadcasting, peaking in the 1980s with the higher availability and practicality of video recording. Though videos were supplanted in the multimedia literature by computer animation, some areas of research – and particularly professional development – remained very active (Wetzel et al., 1994). In the last decade, with the development of video sharing websites like YouTube together with the capacity of mobile phones to record, disseminate and access video instantaneously, the use of video has become ubiquitous. Yet, instructional videos come in many genres, for diverse instructional purposes, and in various instructional settings.

First, video can be used as engaging learning resources, in self-directed learning or to complement to face-to-face teaching, as in the popular "flipped classroom" trend that in contrast to what is now called traditional teaching, promotes lecture time at home and exercises in the classroom. Beyond the fad, this instructional use of video to complement other types of resources is very rich as described later in this section. Secondly, videos can be tutorials demonstrating how to perform a procedure such as mathematic computation, hand manipulation tasks, professional behavior, or software operations. The presence of tutorials of all sorts, in the Do-It-Yourself trend is probably the most striking development of video on the internet (ten Hove & van der Meij, 2015). A third instructional use of video stems from the reflexive practitioner model (Schön, 1987) where novices learn from observing how experts (or non-experts) behave in complex real situations in order to elicit reflection on practice. Alternatively, novices can retrospectively analyze their own behavior recorded in context, which has become much more accessible with technological advances (e.g., Guichon, Bétrancourt & Prié, 2011, for pre-service language teacher). A fourth instructional use is to have students design the videos, as the learning output of active and collaborative instructional approaches, instead of written reports or exams. This approach is particularly interesting when the learning goal is to elicit conceptual or attitude change (Zahn et al., 2014).

All papers in the special issue are to some extent tutorials demonstrating a way to operate computations, motor tasks or software operations. But they can also fit in the first category, particularly Merkt et al. (this issue), Hoogerheide et al. (this issue) and van Wermeskerken et al. (this issue) whose materials include conceptual explanations as well as Boucheix et al. (this issue) who actually provided the video resource to study as a complement to live a demonstration of the procedure.

Regarding the use of video as content resources, most universities now provide their students with recordings of live classes, either as a backup for those who cannot attend, or as a replacement for lecture-style teaching that is assumed to be less engaging for students. The video then serves as a medium that provides access to an event over time and space. More elaborated than mere recording of live classes, short videos are often used in online courses like MOOCs in order to provide a conceptual introduction or procedural modeling of examples. Two papers in this special issue used such videos and explored the effect of the presence (van Wermeskerken et al., this issue) and gender (Hoogerheide et al., this issue) of the instructor during the demonstration. Interestingly, the presence of the instructor did not affect learning outcomes even if learners spent 30% time looking at the teacher. The authors conclude that social presence seems important and could be used to help students direct their attention to relevant aspects of the demonstration (e.g., pointing gestures). In Hoogerheide et al. study, the instructor's gender did not affect learning, nor the interaction with the observer's gender. The authors conclude that maybe other characteristics are more important than gender for teenagers, which is somehow reassuring. An important issue related to the use of this genre of video is the global instructional setting in which they are used and particularly the learning tasks given to the learners (Kirschner & van Merriënboer, 2008). The research shows that audio podcasts, when given as supplementary materials before the lecture, promote students' motivation, engagement and learning outcomes especially when they are accompanied by epistemic questions (Popova, Kirschner, & Joiner, 2014). Conversely, without specific instructions and tasks to perform, such videos can very well elicit an illusion of understanding and a shallow processing, what Lowe (2004) described as an "underwhelming effect" of dynamic visualizations.

Regarding the second use of videos as tutorials, several authors have proposed design recommendations based on the cognitive, instructional, and media literature (Brame, 2016; Morain & Swarts, 2012; ten Hove & van der Meij, 2015; van der Meij & van der Meij, 2013). Only the van der Meij et al. (this issue) paper in the special issue concerns instructional factors external to the material, with the introduction of practice before or after studying the videos, compared to a control condition with the video and no practice. Contrary to intuition, practice either before or after, did not make a difference and students (10–11 y old) learned just as much in the control condition. Though these findings need to be replicated in other situations (and particularly with adult learners), the results of using video for learning to operate software are very encouraging.

No paper in the special issue used video in the reflexive or constructionist instructional approaches aforementioned. It may be worth investigating these instructional settings using the methodology and conceptual framework from the multimedia literature.

5. Some directions for future research on video-based learning

This commentary has examined the papers of the special issue with the aim of deepening the question of why and when videos would benefit learning. Three levels of explanation have been chosen: representational, cognitive–perceptual, and instructional. We are aware that the papers contain much more than what has been selectively discussed here and we invite the readers to refer the papers themselves.

To conclude this commentary, we would like to highlight several methodological issues that in our opinion, deserve some attention in future research. The first issue deals with the nature of content that is conveyed in the dynamic visualization and the relevance of video to convey this content. This question relates to representational issue (why video among other types of dynamic visualizations), cognitive issues (why dynamic visualizations for this content), design issues (how to focus learners' cognitive resources on relevant aspects) and instructional issues (how to shape learners' activity to promote learning). The research could be also attentive to align the video and instructional design to the desired learning outcomes. As mentioned in Berney and Betrancourt (2016), the papers usually present very little detail on the material – the type of visualization, the argumentative structure and so on. This is especially true when the material is 10-min or so video-based instruction and would be practically very hard to fully describe in few words. The provision of the experimental material in open science data bases may be a solution to overcome this difficulty.

The second issue is related to the interaction between design factors and learners' strategy and behaviors. Biard et al. (this issue) noted that students made little use of interactivity, which has been already noted in the literature (Bétrancourt, 2005). The research should investigate online processes in order to identify how the strategies relate to learners' individual characteristics (such as visuospatial abilities, memory capacity but also self-beliefs as in Wong et al., this issue) and how they interact with design issues and scaffold students' learning strategy (Kombartzky, Plötzner, Schlag, & Metz, 2010; Kühl et al., 2011).

A third methodological issue is the tension between the requirements in experimental study to maintain the different conditions as similar as possible except for the independent variables at stake and the ecological validity. Though it seems an easy and fruitless criticism for experimental research in education, this may be particularly worthy of attention if the goal is to provide recommendations for the design of videos. One critical feature that is often absent in experimental research is interactivity, defining the degree and type of control of the pacing of the video. Not only is interactivity a key factor for managing cognitive resources, the research on the use of videos in authentic contexts (Henderson, Selwyn, & Aston, 2017) has shown that students may have a very particular use of control, for example skipping parts they already know or doubling the speed of the teacher's demonstration. As these strategies may be beneficial or critically detrimental to learning, it is important, as mentioned in the second issue, to study learners' behaviors with this kind of material.

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