TECHNOLOGY, PEDAGOGY AND EDUCATION, 2018
VOL. 27, NO. 1, 115–134
https://doi.org/10.1080/1475939X.2017.1407357

Routledge
Taylor & Francis Group

Hypervideo for educational purposes: a literature review on a multifaceted technological tool

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ABSTRACT

The term 'hypervideo' has different interpretations in the scientific literature. The aim of this contribution is to define hypervideo as it is and can be (more optimally) used for teaching and learning purposes. Videos can promote learning by recreating real experiences and dynamic processes, although they do not necessarily enable students to interact with contents and to self-regulate their learning. Hypervideos technically overcome these limitations and add further benefits. However, even though some literature on the topic exists, the concept of hypervideo is not well represented in the scientific community and lends itself to different interpretations. Results show that hypervideo is defined as a dynamic artefact, it should allow navigation control and include additional material; it could also integrate individual or collaborative annotation and automated or manual feedback. So far, most studies have been conducted in artificial settings involving tertiary-level students. Finally, its use is beneficial for students' learning.

ARTICLE HISTORY
Received 20 June 2016
Accepted 24 January 2017

KEYWORDS
Hypervideo; interactive video; multimedia learning

1. Introduction

The rising popularity of video is currently unrivalled; in fact, video is often used in education to enrich lessons or as a supplement to teachers' lectures and explanations. The recent enormous success registered by Massive Open Online Courses (MOOCs), for which short instructional videos are a mainstay to support lectures, is only one confirmation among others.

In fact, using videos to foster learning is not a new issue. A lot of contributions are strongly supported by theoretically grounded arguments. Among the most used frameworks to support this choice, we cite the cognitive theory of multimedia learning (inter alia, Mayer, 1996, 2005) and social cognitive theory (Bandura, 1986), this latter being very often used when applying demonstration-based training with videos (e.g. Grossman, Salas, Pavlas, & Rosen, 2013; Rosen et al., 2010). Both of them support the idea that learning with pictures can be effective for learning, meant both in its cognitive (selection of knowledge and retention or integration in schemata), behavioural (reproduction of processes or procedures viewed in the video) and affective (motivation) components.

However, scientific results on the effectiveness of learning with videos are somewhat inconsistent (Merkt, Weigand, Heier, & Schwan, 2011). Ploetzner and Lowe (2012), in their study about the characterisation of expository animations (that also include videos), revealed how effectiveness is hard to establish due to the great diversity of animations, which makes it difficult to compare the results. In 2006, Hobbs warned against the indiscriminate use of video in classrooms and reported several misuses

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of video, e.g. as a means to fill time, to keep students quiet, to take a break from learning or as a reward for good behaviour.

When used effectively, video can facilitate comprehension and transfer of knowledge, 'especially in those domains where dynamic processes and concrete objects or complex systems need to be observable for a proper understanding of the topic' (Zahn et al., 2005, p. 1). In fact, differently from other static mediums, such as textbooks or images, their spatio-temporal dimension enables videos to dynamically illustrate and visualise knowledge.

Chambel, Zahn, and Finke (2006) built on the claim that video can promote learning by (1) 'replacing' or reproducing real experiences; (2) visualising dynamic processes which might be hard to describe verbally, dangerous to replicate or not observable in reality; and (3) combining diverse symbol systems into coherent media messages.

Despite that evidence, currently the use of videos in educational settings is still often very passive and does not enable students to directly interact with the content. The temporal pace of the sequences only affords the user to explore the video in a linear manner. When possible, classic video players allow the viewer to stop, to go backward and forward, and to play scenes again, but usually they are not thought to support deeper learning processes, such as reflection, elaboration or annotation. As a consequence, the more fruitful features of a video in an educational context are supported only in a limited way. To face these limitations, traditional videos can be transformed into a non-linear and interactive medium called 'hypervideo'. A hypervideo provides users with flexibility, control, autonomy and motivation (Chambel et al., 2006). It can promote and facilitate reflective skills, particularly through learning by design tasks where learners have to adopt an active role of designers and/or collaborate and negotiate meaning, which leads to a better understanding of the topic and to more extended creative, social, cognitive and metacognitive competences (Stahl, Finke, & Zahn, 2006).

Nevertheless, hypervideo is still in some way 'hidden' or at least scattered in the scientific literature. We argue that this is because a univocal and universally recognised definition of what hypervideo is does not exist. Therefore, a first aim of the current review is to propose a comprehensive definition of hypervideo. Furthermore, consistently with what is described above, our second aim is to investigate the current uses of hypervideo for teaching and learning purposes and the possible evidence for hypervideo effectiveness. This results in three main questions the study focuses on:

- What key features define a hypervideo as such?
- What type of research, methodology, content and modality of usage are found in the literature about the use of hypervideo for learning?
- Does hypervideo facilitate knowledge acquisition and learners' motivation?

2. Method

To examine research concerning hypervideo for educational purposes, we searched the following databases: ERIC, Francis, PsycINFO, PSYNDEX plus Literature and Audiovisual Media plus Test, Education Research Complete and SocIND. The following keywords were used for the search: 'Hypervideo', 'Interactive video', 'Interactive hypermedia AND Video', 'Interactive multimedia AND Video' and 'Video annotation'. The keyword 'Hypervideo' was also searched on Google Scholar. The term 'interactive video' has been included because it is often used interchangeably as a synonym of 'hypervideo'. To refine our search, we defined inclusion criteria, according to which the contributions should:

(1) have hypervideo as a central concept;
(2) have been peer-reviewed;
(3) have been published as journal papers, book chapters or scientific reports;
(4) have been published between 2000 and 2015;
(5) be available in English;
(6) refer to a population of students from secondary to tertiary levels;
(7) focus on learning/learners and/or teaching/teachers.

Duplicates were immediately discarded, and the remaining results were then analysed and then selected by one researcher according to the inclusion criteria, on the basis of the abstract. A second researcher then double-checked this selection. In the event of disagreement, the applicability of each criteria was discussed to come to a shared understanding. Finally, a total of 31 articles about hypervideo for educational purposes were selected and reviewed. As some of the articles report multiple studies, the total number of experiments included amounts to 33. An overview of the results of these 33 studies is available in Appendix 1.

3. Findings

3.1. What key features define a hypervideo as such?

The concept of hypervideo was conceived in the early days of hypertext, when Theodor Nelson extended his hypermedia model to include 'branching movies' or 'hyperfilms' (see, for example, Nelson, 1965). The basic idea is simple: to apply the hypertext notion to a video. Today, hypervideo is a heterogeneous artefact, which is defined in the literature in very different ways. In this paragraph, we will first illustrate the features of hypervideo that emerge from the literature, expressly dividing them among basic features – which a hypervideo should necessarily have – and additional features – which a hypervideo does not necessarily have. Second, we will draw on the literature to see which definitions of hypervideo already exist, and third, based on these two points, we will try to outline a new and, if necessary, more complete definition of hypervideo.

3.1.1. Features of a hypervideo emerging from the literature

We identified six key features that constitute a hypervideo (see Table 1 for a summarising overview). The first three are basic features, and the second three are additional ones.

Dynamism refers to the in-motion dimension of the video images (in contrast to the static nature of pictures), which allows learners to better visualise the information to be learnt (e.g. a procedure, something too small or too big to be directly observable in reality etc.), especially when it comes to processes (Höffler, Schmeck, & Opfermann, 2013). It facilitates the comprehension and transfer of knowledge (Chambel et al., 2006). This dimension is more specific to the 'video' object, but it is relevant to keep it explicit, as it constitutes a distinctive trait of a hypervideo which encompasses the video features as well.

Control features represent the idea that a hypervideo can be watched or 'navigated' through a non-linear path, as opposed to a video that has to be enjoyed in a linear manner, from the beginning to the end. In fact, control features include both the typical functions attributed to a 'common' video, i.e. a toolbar with play/pause/stop or rewind/forward buttons, and more complex functions such as indexes, menus or markers on which one can click and which are linked to other resources. In the literature, this distinction is referred to, respectively, as micro- and macro-level activities (Delen, Liew, & Willson, 2014; Merkt et al., 2011). Merkt and colleagues (2011) described micro-level activities as re-reading and lookback actions, which in a hypervideo consist of the possibility to stop or browse the video, while macro-level activities, referring to the navigation through the entire document, correspond to features such as a table of contents and an index. In addition, Delen and colleagues (2014) considered micro-level activities to include play, pause and rewind/forward features, but in their opinion, macro-level activities consist of features such as having at one's disposal supplemental resources, including the possibility of taking notes and to be asked practical questions, which brings us to the features of a hypervideo that will be described below. From a cognitive and a didactical point of view, these features are relevant because on the one hand, they allow learners to moderate the way they interact with the hypervideo, both stopping and re-watching segments of video and avoiding cognitive overload. On the instructional level, this translates into the possibility to adapt learning at their own pace, re-watch important or difficult passages or, alternatively, skip unimportant ones. On the other hand, these features give learners the possibility to choose how to navigate the hypervideo, in a linear or a non-linear manner, according to what better suits their learning and cognitive needs. The organisation of contents in a navigable index

Table 1. Overview of the hypervideo functionalities according to the papers reviewed.

	Basic features			Additional features: Exchange options		
	Dynamism*	Control features	Hyperlinks	Individual video annotation	Collaborative video annotation	Quiz
Cattaneo, Nguyen, Sauli, & Aprea (2015)	•	•	•	•	•	•
Azmy (2013)	•	•	•			
Baepler & Reynolds (2014)				•	•	
Chambel, Zahn, & Finke (2006)		•	•			
Chen (2012)		•	•			
Cherrett, Wills, Price, Maynard, & Dror (2009)		•	•			
Colasante (2011)		•		•	•	
Debevc, Šafarič, & Golob (2008) *Experiments 1 & 2*	•	•	•			
Delen, Liew, & Willson (2014)		•	•	•**		•
Guy, Byrne, & Rich (2014)			•			•
Hulsman & van der Vloodt (2015)				•	•	
Merkt, Weigand, Heier, & Schwan (2011) *Experiments 1 & 2*		•				•
Merkt & Schwan (2014a)		•				
Merkt & Schwan (2014b)		•				•
Mu (2010)				•		
Mujacic, Debevc, Kosec, Bloice, & Holzinger (2012)	•	•	•			
Schwan & Riempp (2004)	•	•	•			
Senchina (2011)	•	•				
Stahl, Finke, & Zahn (2006)	•	•	•			
Stahl, Zahn, Schwan, & Finke (2006)	•	•	•			
Tiellet, Pereira, Reategui, Lima, & Chambel (2010)	•	•	•	•**		
Viel, Rodrigues, Melo, Bueno, Pimentel, & Teixeira (2014)		•	•			
Vural (2013)		•	•			•
Wang (2008)		•				
Yeh & Lehman (2001)		•				
Zahn, Schwan, & Barquero (2002)	•	•	•			
Zahn, Barquero, & Schwan (2004)	•	•	•			
Zahn, Pea, Hesse, & Rosen (2010)	•	•	•	•		
Zahn, Krauskopf, Hesse, & Pea (2010)	•	•	•	•		
Zahn, Krauskopf, Hesse, & Pea (2012)	•	•	•	•		
Zhang, Zhou, Briggs, & Nunamaker (2006)		•				

*The table reports 'dynamism' when it was explicitly cited in the definition of hypervideo, as it is evident that every hypervideo has a dynamic nature; **The tool presented in the contribution presents a video annotation feature, which was not used for the experiment.

or a table of contents can foster learners' browsing and organising competences. At the same time, as nicely illustrated by Merkt and colleagues (Merkt et al., 2011; Merkt & Schwan, 2014b), it is important to train learners with the use of such interactive features so they can really be effective for learning.

A hypervideo is also marked by the presence of *hyperlinks*, i.e. clickable markers, that give access to additional material such as text, pictures, web pages, audio etc. These markers are also referred to as hotspots, interactive points or active points. They have both a spatial dimension – because they can be placed on the video itself to highlight a detail – and a temporal dimension – because they appear for a predetermined time during a video sequence to give the user the time to click on them. The function of hyperlinks is to provide the user with further information to complete, contextualise, deepen or broaden the topic shown in the video. From a cognitive point of view, this function helps to select the important information on which to focus the attention. As well, it supports different learning styles, providing a variety of media formats to learn from. Finally, this feature also relates to some extent to the previous one because the user can choose which markers to navigate through. The research of Tiellet, Pereira, Reategui, Lima, and Chambel (2010) uses the tool Hvet for veterinary surgery classes, which presents a very complete and integrated structure of different materials (e.g. surgical steps, surgical index, surgical text etc.).

The analysis reveals three other features – individual video annotation, collaborative video annotation and quiz – to be specific to a hypervideo, each of which has been identified in a subset of contributions only, leading us to consider them as possible additional functionalities that not all hypervideos automatically share and can be present or not in different pieces of software. These features fall into a category we label 'exchange options', as they allow the learner to interact or to communicate with others.

Individual video annotation concerns the possibility to integrate notes in video-based artefacts while watching them (Colasante, 2011), directly on the video frame or outside of the video area but in the same window or interface. Some tools give the possibility to generate a PDF file, which gathers all of the notes taken with the corresponding frames they refer to (Cattaneo, Nguyen, & Aprea, 2014; Cattaneo, Nguyen, Sauli, & Aprea, 2015). An activity such as note-taking enhances reorganisation, elaboration and recall, and it enables the learner to better connect the new information with prior knowledge (Delen et al., 2014; Mu, 2010). As well, it supports analysis and reflexivity (Colasante, 2011; Rich & Hannafin, 2009; Tripp & Rich, 2012).

Some video annotation tools also allow multiple users to annotate the same video (Hulsman & van der Vloodt, 2015) or to share the annotations in a group-learning environment with online sessions or blog-like interfaces. In the research of Mu (2010) the tool Interactive Shared Education Environment is used to study users' video note-taking behaviours. The system allows users to associate the notes with their video contents and to switch from a private learning space to a public learning space, sharing their own notes with the other users. This feature is what we define as *collaborative video annotation*, and it allows users to share new points of view (Zahn, Pea, Hesse, & Rosen, 2010) or receive feedback from others (peers, supervisors, teachers etc.; Colasante, 2011; Hulsman & van der Vloodt, 2015). In the literature, video annotation – both individual and collaborative – is used to foster analysis and reflective skills, e.g. supporting reflection of pre-service teachers' observation and analysis of their classroom practices (Colasante, 2011) or, in the case of medical students, observing their communication skills for patients' history-taking (Hulsman & van der Vloodt, 2015). Video annotation is a broad topic that would require a dedicated review; here it is cited only limitedly with respect to the satisfaction of our selection criteria.

Finally, the *quiz* functionality gives the user the possibility of 'self-evaluation through use of practice questions' (Delen et al., 2014, p. 313) and offers the learners automated feedback on their performance or progress (Merkt et al., 2011; Merkt & Schwan, 2014a). From an instructional point of view, this function is useful for rehearsal and self-regulation. In the online tool Zaption, the quiz function is pretty well developed, allowing the user to add different kinds of quiz-like questions, with multiple-choice box-checking or text entry (open or numerical). It also allows the author to establish some rules in order to check the scoring, e.g. with commands like 'The answer should be equal to… / should contain…', giving a certain degree of flexibility of the learning environment.

3.1.2. The definition of hypervideo in the literature

To derive from the literature a definition of hypervideo, we can start with a general classification: Zahn, Schwan, and Barquero (2002) categorised three different types of hypervideos with regard to their *non-linear organisation*, as shown in Figure 1. In the first type, short video scenes are linked together. In the second type, a (linear) film is divided into theme-indexed scenes. These two types of hypervideos are *homogeneous*, as they involve one medium only and the user has the impression of a continuous stream of moving pictures. The third type of hypervideo, on the contrary, is *heterogeneous* because 'different symbol systems – texts, pictures, or graphics – are linked to a main video, giving the user the impression of watching a film supplemented by multimedial "footnotes"' (Zahn et al., 2002, p. 154). This last type is the main one adopted by the studies analysed in this review. This could be due to the fact that this classification emerges from one of the most dated contributions we have selected in this review and that, as time passed, technological evolution made more sophisticated options available.

Focusing our attention on heterogeneous hypervideos, and trying to consider all the features highlighted in the previous section, we selected the definition of Stahl et al. (2006) as the most exhaustive among the existing ones, even if it lacks a reference to the three additional features shown above. For them, a hypervideo is a video-based hypermedium 'that combines non-linear information structuring and dynamic audio-visual information presentations … . In hypervideos, video information is linked with different kinds of additional information (like written or spoken texts, pictures, or further videos). Users can mouse-click on sensitive regions within the videos to access the additional information' (p. 286). The authors also note that sensitive regions (or hotspots) have spatial and temporal characteristics, giving the possibility to underline a detail directly in the video and for a specific timeframe. In hypervideos, the video constitutes the 'backbone of the system'.

To define a hypervideo, it is also important to briefly analyse the alternative term 'interactive video'. From the literature considered in this review, in fact, it does not emerge that there is a substantial difference between the terms 'hypervideo' and 'interactive video', and we would then propose to use them as synonyms. However, some contributions consider them as slightly different concepts, as shown in Table 2. Despite these contributions not fitting our criteria – and thus they are not included in the review – it is interesting to consider them for our definitional aim. To sum up, the contribution of Meixner, Matusik, Grill, and Kosch (2014) distinguishes interactive video and hypervideo according to their structure (linear vs non-linear) and some interactive features (without vs with hyperlinks). Moreover, they compare the two objects also with 'annotated videos'. In the model of Locatis, Charuhas, and Banvard (1990), interactive and hypervideo present approximately the same characteristics, but for the second, these characteristics are more pronounced. They also consider the category of 'linear videos'. Finally, for Bonaiuti (2010), the distinction basically lies in a difference in the layout of the interfaces.

Nevertheless, the papers of our review do not fully confirm this distinction. Just to cite some examples, Delen et al. (2014) and Guy, Byrne, and Rich (2014) both spoke about 'interactive videos', but

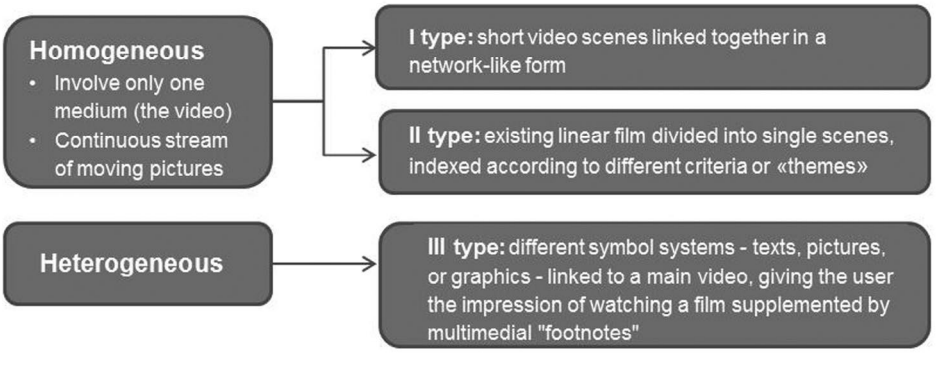

Figure 1. Types of hypervideo (Zahn et al., 2002, p. 154).

Table 2. Differences between interactive video and hypervideo.

Contribution	Interactive video	Hypervideo
Meixner et al. (2014)	• Linear structure • No hyperlinks • Possibility to modify the contents (adding information or altering an existing video or its annotations)	• Non-linear structure • With hyperlinks • No possibility to modify the contents
Locatis et al. (1990)	• Presentation unit is a programme component • Several to many viewing options • Variable but generally high viewer control • Short presentation length • Slow presentation pace • Long dwell time • Mostly real-time action • Narration: normal speech, narrator on camera or voice-over • Transition effects: mostly within segments • Variable transition effect types: variable • Shot progression: establishing and re-establishing shots • Usually non-essential special effects and animations	• Presentation unit is an 'epitome' • Many viewing options • Very high viewer control • Very short presentation length • Fast presentation pace • Short dwell time • Real time, elapsed time action • Narration: accelerated speech, voice-over • Transition effects: within segments only • Variable, but mostly cuts transition effect types • Shot progression: some shots out of context • Essential special effects and animations
Bonaiuti (2010)	• The video fills the entire screen and is provided with hotspots that allow the user to jump to other internal or external resources or parts of the video	• The layout displays different areas or windows (the one with the video, index, control bar, hyperlinks area etc.)

according to Bonaiuti (2010), their structure corresponds to the definition of hypervideo. In opposition, the hypervideo that Debevc, Šafarič, and Golob (2008) referred to looks like an 'interactive video' according to Bonaiuti (2010). The distinctions presented between the terms 'hypervideo' and 'interactive video' could then be relevant from a technical point of view, but they are not confirmed by the concrete use we found in the selected literature, which is in fact more focused on instructional and educational aspects.

3.1.3. An extensive definition of hypervideo

Drawing on the evidence that emerged, we try to give a more complete definition of hypervideo. A hypervideo can be defined as a non-linear video that presents both classical (e.g. play, pause, stop and rewind/forward buttons) and more complex (e.g. table of contents and index) functions to control the navigation of the video stream (corresponding respectively to micro- and macro-level activities), and it is enriched with hyperlinks giving access to additional material (e.g. documents, audio files, images etc.) through specific markers or hotspots. A hypervideo can also be provided with a variety of exchange options which include the possibility to be directly annotated within the interface showing the video, both individually or collaboratively; in the latter case, each user can interact and exchange ideas and points of view with other users with a shared-comments (weblog-like) functionality. Finally, hypervideos allow the users to receive feedback through the above-mentioned communication tools or automatically from the system (e.g. through a quiz feature).

Figure 2 finally illustrates this definition, integrating all the features we identified as distinctive of a hypervideo, distinguishing between:

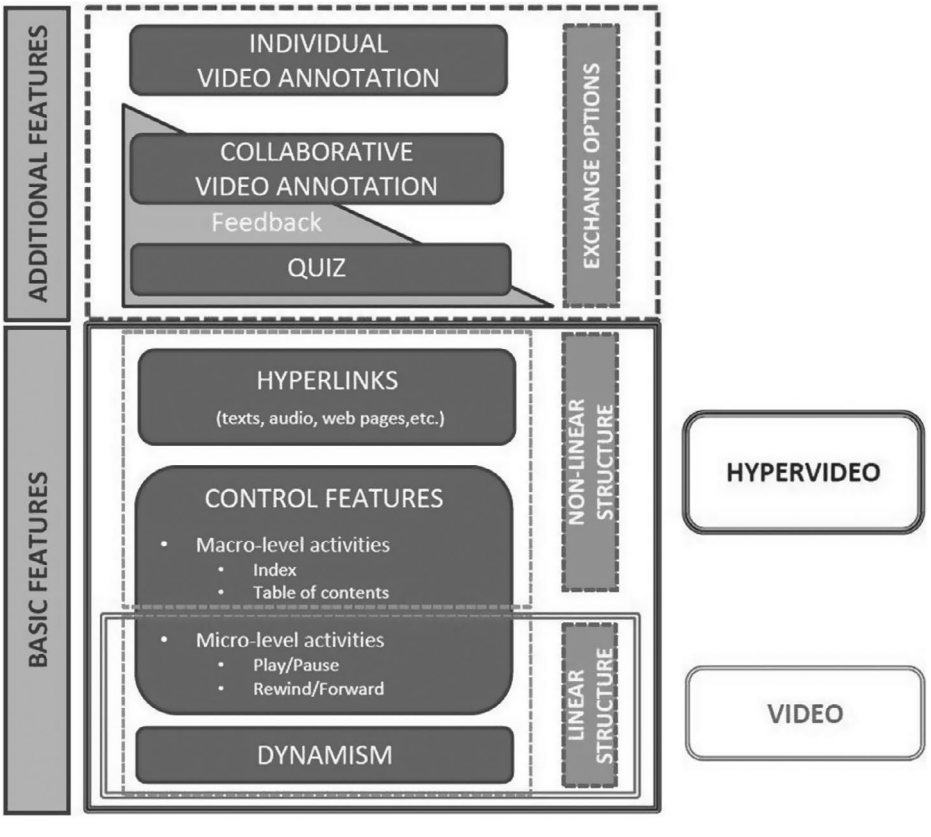

Figure 2. Overview of the basic and additional features of a hypervideo.

- the ones that are typical from a simple video with a linear structure, i.e. dynamism and – concerning control features – the micro-level activities (see the double-lined box in Figure 2);
- the ones that are basic in a hypervideo with a non-linear structure: dynamism, control features (both micro- and macro-level activities) and hyperlinks (see the triple-lined box in Figure 2);
- the ones that are additional in a hypervideo with a non-linear structure: individual and collaborative video annotation as well as quiz (see the dotted-lined box in the upper part of Figure 2). Collaborative video annotation can also (but not only) provide the user with external feedback (e.g. by peers, teachers, supervisors etc.). Similarly, the quiz feature gives the user an 'automatic' feedback, provided by the system itself.
- It is noteworthy that all of these additional features are intended to exploit the very educational activity of reflecting on what is shown by the video itself.

3.2. What type of research, methodology, content and modality of usage are found in the literature about the use of hypervideo for learning?

In this section we provide an overview of the state of the art of research about hypervideo in educational settings (see Table 3 for a summary; Appendix 1 provides more detailed information per paper). Representing the only conceptual contribution of the review, the paper by Chambel et al. (2006) is not considered here.

Results show that hypervideo research is based more on lab than on field studies, and on a quantitative and a mixed-methods rather than a qualitative approach. The target mainly focuses on students from the tertiary level and the contents taught concern more often declarative (both factual and conceptual) rather than procedural knowledge.[1] Declarative topics taught with hypervideo are various, from more scientific (such as biology, engineering, information technology or mathematics) to more humanistic (e.g. history or psychology). The three studies on procedural knowledge are about how to tie different nautical knots (Schwan & Riempp, 2004), veterinary surgery (Tiellet et al., 2010) and optometry (Wang, 2008).

Table 3. Overview of the studies.

	# of studies
Research approach	
Quantitative	18
Mixed	12
Qualitative	2
Type of research	
Lab study	19
Field study	13
Target group	
Secondary	24
Tertiary	5
Other*	3
Content	
Declarative	28
Procedural	3
Both	1
Modality of usage	
Hypervideo used individually	19
Learning by design collaboratively	6
Learning by design individually	2
Hypervideo used in groups	1
Hybrid	2
Multiple uses among the above-mentioned ones	2

*This category includes 'participants from different backgrounds' (Zahn et al., 2002, 2004) and 'English as a foreign language students' (Yeh & Lehman, 2001).

Concerning the modality of usage, we could identify five main categories: (1) the hypervideo is used individually by students, e.g. in a computer lab or in a e-learning setting; (2) the hypervideo is realised by students collaboratively or (3) individually, according to a learning-by-design approach (Stahl et al., 2006); (4) the hypervideo is used by students in groups; and (5) the hypervideo is used in more than one of the above-mentioned ways: for example, in the study by Mu (2010), hypervideo is watched first by students individually and then re-watched in groups; similarly, Senchina (2011) reported a study where the hypervideo is shown in a plenary first and then envisages a group and an individual activity. From this categorisation we can also derive another interesting observation: in options 1 and 4 the hypervideo is made interactive directly by the researchers, whereas in options 2 and 3 the design and realisation of the hypervideo are given to learners.

3.3. Does hypervideo facilitate knowledge acquisition and learners' motivation?

To answer this third question, we collected and analysed the results of the studies with regard to students' knowledge acquisition and motivation. Of a total of 33 studies, 18 had a measure of knowledge acquisition and 4 of motivation. The remaining studies measured other dimensions (e.g. usability, satisfaction, self-regulated learning strategies etc.) that will be briefly presented at the end of this section.

3.3.1. Knowledge acquisition

Knowledge acquisition is measured in very different ways, differing by study. The most common way is to use a pre-/post-test design, which allows students' initial knowledge about a specific topic to be assessed and compared with their knowledge after the exposure to an interactive video-based instruction. Normally, this type of study also foresees a control group that is not exposed to the interactive video-based instruction but receives a traditional (with materials such as printed papers, textbooks etc.) or a common video instruction. As a summary, 17 out of the 18 studies that measured knowledge acquisition did so through a pre-/post-test and control-group design (more details are available in Table 4). The only study without a control group is the one by Cherrett, Wills, Price, Maynard, and Dror (2009). In their study, students watched an interactive video about risk assessment in civil engineering and needed to identify and describe some hazards and assess their likelihood of ending in an accident. As a primary result about knowledge acquisition, 60% of the students were able to recognise the major risks. Even though the studies are slightly different from each other, and hence, the results should be read cautiously, the evidence arising from the literature overall highlights a positive effect of interactivity in videos on learners' knowledge acquisition. Some papers do not fully corroborate this thesis: a set of studies shows no differences between hypervideo and video and/or traditional instruction (Merkt & Schwan, 2014a, 2014b; Wang, 2008; Zahn, Barquero, & Schwan, 2004), but in this case, the use of videos is at least as effective as traditional instruction. Finally, only the contribution by Merkt and colleagues (2011, experiments 1 and 2) finds that illustrated textbooks or common videos outperform hypervideos.

3.3.2. Motivation

Motivation is measured in four studies (Baepler & Reynolds, 2014; Cattaneo et al., 2015; Chambel et al., 2006; Chen, 2012). In the study by Chen (2012), the Instructional Material Motivational Survey, which evaluates overall learning motivation, was used. Baepler and Reynolds (2014) asked students to evaluate one item about motivation, whereas in the paper by Chambel et al. (2006), it is an outcome that results from different experiments: 'From our studies and experiences, we conclude that students are more motivated to watch the videos in this type of hypervideo than in traditional settings, as the process becomes more flexible and engaging' (p. 39). Finally, Cattaneo and colleagues (2015) measured perceived motivation through interviews with teachers. Findings from all four studies show that a hypervideo-based instruction increases students' motivation.

Table 4. Overview of the studies measuring knowledge acquisition and their results.

		Results*		
Conditions	# of studies	HV+	HV=	HV–
Hypervideo versus Video	8	• Chen, 2012 • Delen et al., 2014 • Merkt & Schwan, 2014b** • Schwan & Riempp, 2004 • Tiellet et al., 2010 • Zahn, Krauskopf, et al., 2010 • Zahn, Pea, et al., 2010	• Merkt & Schwan, 2014b** • Zahn et al., 2004	
Hypervideo versus No Video	2	• Mujacic et al., 2012	• Wang, 2008	
Hypervideo versus Video versus No Video	4	• Zhang et al., 2006 • Merkt & Schwan, 2014a**	• Merkt & Schwan, 2014a**	• Merkt et al., 2011, experiments 1 and 2
Video with more interactivity versus Video with less interactivity	2	• Vural, 2013 • Yeh & Lehman, 2001		
Hypervideo only	1	• Cherrett et al., 2009		

*'HV+' = the hypervideo condition outperformed the other conditions; 'HV=' = the hypervideo condition was as effective as the other conditions 'HV–' = the hypervideo condition underperformed relative to the other conditions; **These studies appear in both categories because the results vary according to the variables.

3.3.3. Other dimensions measured

We report here some other dimensions that have been tested in the papers of our review, even if the list is not exhaustive: satisfaction (Cattaneo et al., 2015; Tiellet et al., 2010), usability and acceptance of the tool (Baepler & Reynolds, 2014; Cattaneo et al., 2015; Debevc et al., 2008; Wang, 2008; Zahn et al., 2004) and perceived efficacy (Cattaneo et al., 2015; Cherrett et al., 2009; Colasante, 2011; Guy et al., 2014). The evidence shows that usually hypervideo is considered an effective and satisfactory learning tool; even if the software changes, it is usually highly rated as easy to use and well accepted.

4. Discussion and conclusion

This article reviewed the status of the research of the last 15 years about hypervideo for educational purposes on the basis of 33 studies. In particular, it aimed to understand how hypervideo is defined and used for teaching and learning purposes, and with what results.

4.1. Which key features define a hypervideo as such?

In the literature, a unique and shared definition of hypervideo does not exist. The review showed that there are three common elements that are specific to almost every hypervideo, and three other elements that can be considered as additional. Concerning the three fundamental features of a hypervideo, we have, first, its dynamic nature because the 'backbone of the system' is videos. Second, in hypervideos, it is possible to control the navigation, with the classical buttons stop, pause, rewind or forward, or through more advanced non-linear features, such as a table of contents menu or index. Videos could then be watched in a hypertext-like manner, according to the pace and the cognitive needs of the learner, who can follow different (pre-defined) paths of navigation and discovery. Third, hypervideos present the possibility to integrate other contents and media (text, audio, web pages etc.) through hyperlinks that have spatial and temporal dimensions. This provides learners with the possibility to access a deeper level of knowledge and different points of view.

Three other features are considered as optional ones because they are present only in some hypervideo pieces of software and can be grouped under the name 'exchange options', namely the possibility to directly annotate the video (individual video annotation), to share comments in a blog-like manner about the hypervideo (collaborative video annotation) and to insert quizzes and receive automated feedback. All of these features allow reflection about the contents and deeper understanding, which is an important aspect of learning with videos. According to these results, Figure 2 proposes a visual representation of our resulting and comprehensive definition of hypervideo.

The two sets of features somehow mirror the two main frameworks which we briefly cited in the introduction as being mostly used when investigating learning with videos: in fact, the first three can be related to multimedia learning, and to the exploitation of hyperlinks and segmentation processes to connect pieces of information of several formats into a non-linear and self-regulated path. The second three are closer to social learning theory and demonstration-based learning, and bring to the possibility of exploiting the video source as a means for analysing behaviours, and then to reflect and eventually evaluate professional practice. Taken together, they also confirm the potential scholars identify in videos when they refer to Norman's (1993) distinction of two main cognitive modes: experiential and reflective. The hypervideo tool seems to integrate both kinds of affordances, depending on if we look at the first or the second set of features.

4.2. What type of research, methodology, content and modality of usage are found in the literature about the use of hypervideo for learning?

Concerning our second research question, we can draw some general statements:

- The focus is more on quantitative, experimental laboratory studies than on qualitative field studies; the figure of the teacher/trainer as well as of the instructional choices behind the implementations of hypervideo in a learning context are actually under-represented if not completely missing. In almost all studies, the hypervideo is realised or chosen by the researchers to fit the aims of the experiment; thus, it is rarely part of an in-field instructional design process. Additionally, the productive process towards the preparation of a hypervideo is hardly ever investigated. The productive process is connected to the peculiar features of a hypervideo, where we observe that none of the studies presented here exploit or combine all the two sets of features (roughly corresponding to the hyperlinking and annotation functions) at the same time to observe their effect on knowledge acquisition. Of course, using all of them within the same study would make it difficult to control for their individual effects. However, it would be worthy to investigate these features from the point of view of the educational user who is producing a hypervideo for learning; the production process has in fact important consequences depending whether you intend to exploit either one or the other function. To what extent the combination of the two is more profitable than just selecting one of them is still a question to be investigated.
- The studies are fully student and learning centred; then, the question about how hypervideo changes the teacher's role and teaching practices is still an open one too. This can be combined with what has already also been shown by Zahn, Krauskopf, Hesse, and Pea (2010) about the need to deepen the conditions and criteria for assuring effective strategies and structured scenario design. Further research should be devoted to an in-depth analysis of the entire process of designing a hypervideo, from selecting or self-producing a raw video, through making it interactive, to integrating it into an instructional scenario for a learning activity.
- With regard to the use of hypervideos, the majority of contributions suggest individual use, which is not surprising as some theory-driven evidence from cognitive psychology emphasises the importance of giving the user control of the tool. A second and alternative use, supported by more socio-constructivist approaches, emphasises the effectiveness of involving students in collaborative processes. Once again, an instructional perspective on the potential of hypervideo as a teaching tool is missing. We are perfectly aware of the importance of directly motivating students in learning tasks; however, we emphasise the relevance of investigating more the role teachers can play when integrating hypervideos in their instructional activities as the other side of the same coin. After all, we are increasingly conscious that using technology for learning requires pedagogical awareness and teachers' intervention to be effective (inter alia Hattie, 2009; Lee, Waxman, Wu, Michko, & Lin, 2013).
- Concerning the field of application, there is an over-representation of studies focusing on the tertiary level and only some on the secondary level. Overall, there is a lack of studies conducted in the Vocational and Professional Education and Training (VET/PET) context. There are much fewer studies concerning procedural rather than declarative knowledge, which is consistent with there being no studies about VET. Considering the procedural nature of knowledge treated in the VET field and combining it with the added values of using (hyper)videos to learn procedural knowledge, we emphasise the need for developing research on the use of hypervideos to foster vocational education.

4.3. Does hypervideo facilitate knowledge acquisition and learners' motivation?

Of 33 studies reviewed, 18 addressed the question of knowledge acquisition, and 17 of them compared a hypervideo-based instruction with one or more other conditions (video based, without video etc.). In 17 out of these 18 studies, students who were exposed to a hypervideo-based instruction either outperformed their fellows in other conditions (13 studies), or were at least as effective as the ones in the other conditions in terms of learning (4 studies). In only one case (Merkt et al., 2011), instruction without video led to better learning outcomes than a hypervideo instruction, but in this case, the fact

that learning outcomes were measured through an essay task on historical contents could have also played a role. Most of these studies discuss these results in the light of some of the multimedia learning principles (Mayer, 1996, 2009), arguing either that a good hypervideo contributes to reducing the amount of cognitive resources needed to process information, or that activating the learners and making them interact at their own pace, with their own strategies, navigating the content autonomously, fosters more effective learning.

When it comes to motivation, the fact that it has only been assessed in 4 of the 33 studies (all of them supporting that a hypervideo-based instruction is very motivating for students) is somehow surprising per se, as multimedia materials and learner control are often used to increase motivation. However, due to the small number of studies that fell into this category, little can be said about this dimension, which suggests the need for further investigations.

Many articles assessed other dimensions, some of them focused more on the tool itself (e.g. usability or acceptance), and some focused more on the learner's experience (satisfaction, perceived usefulness etc.). More broadly, and also coming back to social learning theory, two important aspects are still worthwhile to investigate: transfer of knowledge from theory to practice (including reproduction processes) and retention of knowledge over time.

To sum up, we can say that, so far, the concept of hypervideo is still relatively innovative, and its use to support learning remains limited to a few experiences, particularly to a learner-centred individual use of this technology in controlled environments within tertiary-level institutions. Nevertheless, given the considerable potential hypervideos have for supporting learning and teaching processes, more research should be conducted to investigate the conditions under which hypervideos can effectively be integrated in instructional scenarios, and particularly in the vocational domain (e.g. Cattaneo, Nguyen, & Aprea, 2016), where the use of videos to reproduce unusual tasks, risky procedures and complex situations, as well as to integrate professional and methodological competences without artificially separating them, seems to be worthwhile.

Of course, the current review suffers from some limitations, stemming, for example, from the restriction of the criteria used for selecting the basic contributions: extending the keywords to include other forms of multimedia as well as considering the huge literature on multiple representations and learning could bring additional strength to the aims of the present article. In particular, there is a big use of hypervideo outside of academic settings, which it could be interesting to consider to expand the aim of this work and to fully understand how hypervideo is being used. Other limitations are linked more to the set-up of an experimental study. For example, in some studies, more variables are manipulated simultaneously, which makes it difficult to understand which one(s) is(are) responsible for the effect. In other cases, the content or the procedures in hypervideos and without hypervideo conditions are not equivalent, so it is not possible to compare them effectively. This point was also stated by Tversky, Bauer Morrison, and Betrancourt (2002) about static and animated graphics. Nevertheless, these experimental limitations are valid only for a few studies.

In conclusion, the current work makes an advancement in defining a complex object such as the hypervideo and in putting together scattered contributions on the topic. This is already a useful result in order to design new learning activities with hypervideos and, at the same time, to highlight further research aims for the benefit of learners in every domain.

Note

1. According to Anderson et al. (2001), we refer to the first when encompassing the basic elements of a discipline as well as their interrelationships, while the second is basically the 'knowledge of how to do something'.

Acknowledgements

We thank Carmela Aprea and Osvaldo Arrigo for their engagement in supporting the project; Lorenzo Cantoni, Beatrice Ligorio and Carmen Zahn for their long-lasting support and helpful feedback; and Anh-Thu Nguyen for the collaboration in the starting phase of the project.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The review presented here is part of IV4VET (Interactive Videos for Vocational Education and Training), a project supported by the Swiss State Secretariat for Education, Research and Innovation [project #13-1536], which commissioned its development to the Swiss Federal Institute of Vocational Education and Training.

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Appendix 1. Details of the reviewed references

ID	Type of research/ Research approach	Participants (*N*, kind, age, gender)	Topic/Type of knowledge	Conditions
Cattaneo, Nguyen, Sauli, & Aprea (2015)	Field study Mixed methods	*N* = 13 VET teachers *N* = 332 VET students	Different VET curricula Declarative and procedural	N/A
Azmy (2013)	Lab study Quantitative	*N* = 60 university students of a pre-service teacher programme 44 women, 16 men	Instructional models and samples (instructional technology) Declarative	Navigation control (Free navigation vs Free navigation with advisement) x Navigation links (Video-based links vs Video/ text-based links)
Baepler & Reynolds (2014)	Field study Mixed methods	*N* = 43 university students 23 women, 20 men	Writing Declarative	Writing and modern cultural movements vs Writing about land and the environment
Chambel, Zahn, & Finke (2006)	N/A	N/A	N/A	N/A
Chen (2012)	Lab study Quantitative	*N* = 76 First-year university students 41 women, 35 men	Information technology (Microsoft Office skills) Declarative	Interactive thematic video vs Traditional video based
Cherrett, Wills, Price, Maynard, & Dror (2009)	Field study Quantitative	*N* = 75 2nd-year university civil engineering students	Civil and environmental engineering (risk assessment) Declarative	N/A
Colasante (2011)	Field study Mixed methods	*N* = 24 23 university physical education students + their class teacher Mean age (students): 19.513 women, 11 men	Physical education ('Methods of teaching physical and sport education') Declarative	N/A
Debevc, Šafarič, & Golob (2008) *Experiment 1*	Lab study Quantitative	*N* = 10 Electrical engineering university students Mean age: 242 women, 8 men	Magnetic suspension system Declarative	Hypervideo individually (experimental group only)
Debevc, Šafarič, & Golob (2008) *Experiment 2*	Lab study Mixed methods	*N* = 13 Electrical engineering university students Mean age: 22.213 men	Magnetic suspension system Declarative	Hypervideo individually (experimental group only)
Delen, Liew, & Willson (2014)	Lab study Quantitative	*N* = 80 University and graduate students	Renewable energy sources (hydro-power, wind energy, geothermal energy, biomass energy, biofuel energy and solar power) Declarative	Enhanced video (with functions enabling micro- and macro-level activities) vs Common video (with functions enabling only micro-level activities)
Guy, Byrne, & Rich (2014)	Field study Quantitative	*N* = 177University students	Human anatomy and physiology Declarative	N/A
Hulsman & van der Vloodt (2015)	Field study Mixed methods	*N* = 25Fourth-year university medical students 15 women, 10 men	Medical communication skills (history-taking consultation with a simulated patient) Declarative	N/A

Merkt, Weigand, Heier, & Schwan (2011) *Experiment 1*	Lab study Quantitative	*N* = 60 Secondary school students Mean age: 18.20 31 women, 29 men	History Declarative	Common video vs Enhanced video vs Illustrated textbook
Merkt, Weigand, Heier, & Schwan (2011) *Experiment 2*	Field study Quantitative	*N* = 156 Secondary school students Mean age: 17.31 107 women, 49 men	History Declarative	Common video vs Enhanced video vs Illustrated textbook
Merkt & Schwan (2014a)	Lab study Quantitative	*N* = 81 University students Mean age: 22.90 61 women, 20 men	History Declarative	Enhanced video (table of contents, index, stop, browsing) vs Common video (stop and browsing) vs Non-interactive video vs Illustrated textbook (functionally equivalent to the enhanced video)
Merkt & Schwan (2014b)	Field study Quantitative	*N* = 64 Secondary school students Mean age: 14.84 38 women, 26 men	History Declarative	Video (Common video vs Enhanced video) x Task (simple search vs complex essay writing) x Training (search vs control)
Mu (2010)	Lab study Mixed methods	*N* = 59 University students Mean age: 21.5 34 women, 25 men	Geology (earthquakes, hurricanes) Declarative	Interface (Smartlink ISEE vs non-Smartlink ISEE interface) x Type of questions (Comprehension vs Analysis)
Mujacic, Debevc, Kosec, Bloice, & Holzinger (2012)	Lab study Quantitative	*N* = 88 Engineering university students	Engineering (digital systems) Declarative	Traditional learning model of lectures and lab work (control group) vs Hypermedia model in conjunction with traditional learning techniques
Schwan & Riempp (2004)	Lab study Quantitative	*N* = 36 University students Mean age: 23 8 women, 24 men	Tying of nautical knots Procedural	Video type (Non-interactive vs Interactive environment) x Difficulty of knot (double half hitch vs cleat wind vs anchor bend vs bowline)
Senchina (2011)	Field study Qualitative	*N* = 88 University students	Physiology (ethical aspects of human subjects) Declarative	N/A
Stahl, Finke, & Zahn (2006)	Field study Mixed methods	*N* = 10 to 16 University students for each course, for 4 courses	Psychology (e.g. communication techniques and conflict management) Declarative	First course (without instructional programme) vs Second course (with instructional programme on how to use the features of hypertext consciously)
Stahl, Zahn, Schwan, & Finke (2006)	Field study Qualitative	*N* = 10 to 16 University students for each course, for 4 courses	Psychology (e.g. communication techniques and conflict management) Declarative	First course (without instructional programme) vs Second course (with instructional programme on how to use the features of hypertext consciously)
Tiellet, Pereira, Reategui, Lima, & Chambel (2010)	Lab study Mixed methods	T1: *N* = 51, T2: *N* = 52 University students	Veterinary surgical techniques (ovariosalpingohisterectomy in dogs) Procedural	T1: Hypervideo vs Video T2: Everybody used the hypervideo

(*Continued*)

Appendix 1. (*Continued*)

ID	Type of research/ Research approach	Participants (*N*, kind, age, gender)	Topic/Type of knowledge	Conditions
Viel et al. (2014)	Field study Quantitative	*N* = 117 92 university students from the distance-learning group (mean age = 30) + 25 university students from the traditional classroom group (mean age = 23)	Database design Declarative	Traditional lesson vs Distance-learning course
Vural (2013)	Lab study Quantitative	*N* = 318 Teacher education students 205 women, 113 men	Computer literacy Declarative	Question-embedded interactive video (QVE) vs Interactive video environment without the question component (IVE)
Wang (2008)	Lab study Mixed methods	*N* = 112 (Part I), 103 (Part II) First-year optometry students	Optometry Procedural	Virtual lab tool vs Traditional laboratory
Yeh & Lehman (2001)	Lab study Mixed methods	*N* = 111 English as a Foreign Language students Mean age: 20	English Declarative	Variation of control (Learner control vs Program control) x The use of advance organisers (Presence vs Absence of advance organisers) x Students' English-learning strategy ability (High ability vs Low ability)
Zahn, Schwan, & Barquero (2002)	Lab study Quantitative	*N* = 30 Different backgrounds	Cellular biology Declarative	Knowledge background (Biology experts vs Media experts vs Non-experts) x Video clip (Clip 1: typical instructional animation vs Clip 2: scientific film vs Clip 3: TV documentary)
Zahn, Barquero, & Schwan (2004)	Lab study Quantitative	*N* = 64 Different educational backgrounds Mean age: 26.8 39 women, 35 men	Biology (lakes as ecosystems) Declarative	Number x Position of links For a total of 5 groups: Group 1: 15 links sequential; Group 2: 30 links sequential; Group 3: 15 links clustered; Group 4: 30 links clustered; Group 5: no links (control group)
Zahn, Pea, Hesse, & Rosen (2010)	Field study Mixed methods	*N* = 48 1st and 2nd year university students Mean age: 22.2 33 women, 15 men	History Declarative	Collaborative video (WebDIVER) vs Video player and text (Apple Quicktime combined with a word processor)
Zahn, Krauskopf, Hesse, & Pea (2010)	Lab study Mixed methods	*N* = 234 Secondary school students Mean age: 15.9 164 women, 70 men	History Declarative	Digital video technology ('Diver/WebDIVER' vs 'Player and text') x Shared media-related goals ('Creating Dives' vs 'Creating annotated movies')
Zahn, Krauskopf, Hesse, & Pea (2012)	Lab study Quantitative	*N* = 148 High school students Mean age: 16.2 65 women, 81 men	History Declarative	Forms of guidance (Social interaction-related vs Cognitive task-related guidance) x Video tool (Selective video tool vs Integrative hypervideo tool)
Zhang, Zhou, Briggs, & Nunamaker (2006)	Lab study Quantitative	*N* = 138 University e-learning students	Internet search engines Declarative	E-learning environment with hypervideo vs E-learning environment with non-interactive video (only with 'stop' and 'pause' buttons) vs E-learning environment without video vs Traditional classroom environment