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Learning with videos vs. learning with print: The role of interactive features

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Abstract

Two complementary studies, one in the laboratory and one in the field, compared the usage patterns and the effectiveness of interactive videos and illustrated textbooks when German secondary school students learned complex content. For this purpose, two videos affording different degrees of interactivity and a content-equivalent illustrated textbook were used. Both studies showed that in contrast to previous studies working with non-interactive videos, the effectiveness of interactive videos was at least comparable to that of print, probably due to the possibilities provided for self-regulated information processing. It was shown that the interactive features of the videos were used spontaneously. However, features enabling micro-level activities, such as stopping the video or browsing, seemed to be more beneficial for learning than features enabling macro-level activities, such as referring to a table of contents or an index. This finding is explained by students' misconceptions about the use of features enabling macro-level activities.

Keywords: Digital videos; Learning with videos; Learning with media; Media comparison

1. Introduction

Besides being a major component of students' media experience in their leisure time (Feierabend & Rathgeb, 2008, 2009), videos are one of the most frequently used media in classroom settings (Corporation for Public Broadcasting, 1997, 2004; Feierabend & Klingler, 2003). With the growing affordability and resulting availability of video production tools, this trend is unlikely to change in the years to come. For instance, in history education videos may serve two purposes. First, contemporary videos are considered as historical sources suitable for providing vivid and broad insights into more recent and most recent history (Paschen, 1994). Second, contemporary feature movies can be used to analyze societal and political views that were predominant at the times the movies were shot (Stoddard & Marcus, 2010). Given these fruitful modes of utilization, it is not surprising that local standards for history education mention videos as one crucial source students should use when deliberating about historical events (Hessisches Kultusministerium, 2010; Ministerium für Kultus, Jugend und Sport Baden-Württemberg, 2004; Sächsisches Staatsministerium für Kultus, 2009; Verband der Geschichtslehrer Deutschlands, 2006).

Based on these considerations, it is evident that videos are an integral component of the educational environments students face these days. However, from the perspective of educational psychology, the status of video as an effective learning medium has not gone undisputed, particularly in comparison to print. Yet studies in which knowledge acquisition was lower for video than for text, typically presented video in a broadcast mode in which it was not possible for the viewers to control the video's flow of information (e.g., Furnham & Gunter, 1985; Gunter & Furnham, 1986; Walma van der Molen & van der Voort, 2000). In contrast, recent digital forms of video give the viewers the opportunity to (inter-) actively control its presentation. Accordingly, in the present article, two empirical studies are described that examined the effectiveness of interactive features in videos in comparison to an illustrated textbook.

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2. Comparing knowledge acquisition with text and with video

Even though the effectiveness of video was found to be comparable to traditional classroom instruction (Michel, Roebers, & Schneider, 2007), the use of videos for learning purposes is not undisputed. Doubts arise from several studies comparing the effectiveness of videos to content-equivalent print (e.g., DeFleur, Davenport, Cronin, & DeFleur, 1992; Furnham & Gunter, 1985, 1987; Gunter, Furnham, & Gietson, 1984; Gunter, Furnham, & Leese, 1986; Walma van der Molen & van der Voort, 2000; Wicks & Drew, 1991; Wilson, 1974). Whereas for children (that assumedly lack reading proficiency) and low complex material (for example, children's news), retention and understanding were equal or even in favor of videos (Furnham, de Siena, & Gunter, 2002; Walma van der Molen & van der Voort, 1997, 2000), for adolescent or adult viewers and complex matters, several studies repeatedly found videos to be inferior to print when it came to recalling the facts mentioned in the medium - even when presentation time was held constant over the different conditions. These findings were replicated for different genres such as news broadcasts (Furnham & Gunter, 1985; Gunter & Furnham, 1986; Gunter et al., 1986; Walma van der Molen & van der Voort, 2000), political broadcasts (Gunter et al., 1986) and television commercials (Furnham, Benson, & Gunter, 1987). A similar advantage has also been reported for print over spoken text. In this case, a comprehension advantage of spoken text was shown for short and semantically poor content; however, print was found to be better suited for complex and semantically rich content (Kürschner & Schnotz, 2008).

One possible reason for these differences is the amount of control the recipient can exert over his or her information processing in the respective medium. Whereas in the print conditions of the aforementioned studies (e.g., Furnham et al., 2002; Furnham & Gunter, 1985, 1987; Gunter et al., 1984, 1986; Walma van der Molen & van der Voort, 2000) recipients were allowed to reread relevant passages, skip unimportant ones, and adjust the reading pace to their individual cognitive needs, in the video condition the films were shown in a strictly medium-controlled fashion, without giving the viewers any possibility of changing pace or sequence of the presentation. Thus, the observed deficiencies of videos can probably be attributed to the restricted range of activities related to the control of the transient flow of information.

3. Micro-level and macro-level activities in text processing

For text, several studies related to reading comprehension have demonstrated the importance of self-regulated information processing on a local level (Bazerman, 1985; Coté, Goldman, & Saul, 1998; Garner, 1987; Hyönä, Lorch, & Kaakinen, 2002; Hyönä & Nurminen, 2006; McNamara, Levinstein, & Boonthum, 2004). Not only do skilled readers adapt their reading pace to the complexity of the text and to their cognitive needs, but they also actively reread important or difficult passages, skip unimportant or uninteresting passages, quickly browse through comprehensive texts, and stop reading for a moment to engage in self-explanations (McNamara et al., 2004). Studying overt reading strategies in informational texts, Coté et al. (1998) found 4th and 6th graders' reading strategies to be flexible and adaptive. Students used their prior knowledge to understand the texts and actively used backtracking and rereading of difficult passages they did not understand. Such processes of backtracking and rereading helped students to remember content. These findings are corroborated by eye-tracking studies by Hyönä et al. (2002) and Hyönä and Nurminen (2006). They could show that successful readers deliberately use lookbacks and re-readings of the text as effective strategies for enhancing their memory and comprehension of the text content.

In the following, the term *micro-level activity* will be used to describe re-readings and lookbacks, because they mainly serve to control information processing on a local text level referring to navigation through single words, sentences, or short paragraphs. The usefulness of micro-level activity can be assumed for all forms of printed texts – from short scientific abstracts to voluminous books. Additionally, the term *macro-level activity* will be used to describe text related activities on a more global level referring to navigation through the entire text. Macro-level activity includes the use of top-down text organizers such as tables of contents or indexes to locate, relate, and compare relevant text parts. It is obvious that this kind of activity is hardly useful for short texts, but is a crucial component for working efficiently with comprehensive texts. However, these skills at both the micro- and macro-level are rarely taught explicitly (Guthrie & Mosenthal, 1987), but are expected to be acquired by practice instead (Armbruster & Gudbrandsen, 1986). Rouet and Coutelet (2008) found that some students between the 3rd and 7th grades progress from simple and inefficient search strategies, like browsing through the pages, to top-down search strategies using text organizers, such as tables of contents and indexes, when searching for information in books. The developmental sequence identified in their studies was browsing, followed by the use of the table of contents, followed by the use of the index. Nevertheless, a substantial proportion of the 7th grade students had not yet developed the more advanced modes of locating information. However, young adults (~20 years old) seem to master locating information in textbooks using an index quite well (Yussen, Stright, & Payne, 1993). From research about locating information in textbooks, it still remains unclear what happens if the use of these features has to be incorporated into more comprehensive forms of information processing when participants need to gather information from multiple sections of a medium and locating specific information is just a subgoal serving the superordinate goal of summarizing a medium's content. In this case, the use of the table of contents and the index could even reduce the scope the person considers when gathering information, leading to a neglect of information that could be found outside the selected sections.

By integrating both micro- and macro-level activities, Guthrie (1988) proposed and empirically tested a

comprehensive, five step model of information processing in print. First, driven by internal or external demands, the reader must formulate a reading goal. Second, the reader has to identify relevant sections of the text, which includes browsing textbook chapters for appropriate information, using the chapter structure for search cues. Applied to entire textbooks, it can be assumed that this step also relies on macro-level activities, such as using tables of contents and indexes to find a suitable chapter or suitable pages in a book. If more than one relevant section is identified, the reader also sequences his subsequent inspection of the identified chapters. Third, the reader must extract the details from the sections identified and sequenced in step 2. During this step, micro-level activity is crucial, as the reader actively tries to understand specific information. Fourth, the information is integrated with the readers' prior knowledge. When indicated, goals have to be reformulated or new categories of information must be sought. This may lead to a recycling of the previous steps of information processing (step 5). Guthrie (1988) found that the efficiency of information processing in print depends on the speed and accuracy in which these steps are executed. Performance on steps 2–5 accounted for 68% of participants' variance in general search performance. In support of these tasks, textbooks typically provide a number of features that enable certain micro-level or macro-level activities. This includes the use of appropriate font types and sizes, headings, numerations, tables of contents, and indexes, which have all been shown to contribute positively to ease and quality of text processing (Brooks, Dansereau, Spurlin, & Holley, 1983; Glynn & di Vesta, 1979; Lockhead & Crist, 1980; Lorch & Chen, 1986; Rouet & Coutelet, 2008; Yussen et al., 1993).

4. Processing activities in videos

Turning back to the features of traditional educational videos that were used in the studies by Furnham and colleagues (e.g., Furnham et al., 2002; Furnham & Gunter, 1985, 1987; Gunter et al., 1984, 1986) and by Walma van der Molen and van der Voort (2000), comparable affordances for appropriately processing the video's content were missing. The transitory nature of films leads to additional difficulties that print does not present. Transient information needs to be continuously processed in the working memory. Because the recipients' cognitive resources in the working memory are limited (Sweller, van Merrienboer, & Paas, 1998), transient information can result in a cognitive overload if there is a mismatch of the presentation pace and the recipients' cognitive capacities. Following the argumentation of Lowe (2004), such a mismatch could lead to deficient learning outcomes due to an overwhelming effect. As the information in videos is transient, the consequence of not attending to the information presented in the video may be a loss of relevant information (Sturm, 1984).

This difficulty should be especially prevalent for complex pictorial information lasting for several minutes. Research on animations has shown that cueing (e.g. de Koning, Tabbers, Rikers, & Paas, 2007) can help the recipients handle transient information by highlighting relevant aspects of a presentation. However, these effects were only shown for short and recurring events such as cardiac cycles (de Koning et al., 2007). Thus, the successful implementation of cueing is questionable if longer and non-recurring events lasting for more than a few moments are depicted, because information still remains transient when cueing is used. In the case of videos, professionals have developed a number of design principles to keep complexity at a level manageable by the users. For example, they decompose complete scenes into a sequence of shots which focus on one important event by using different perspectives or zooms (Bordwell & Thompson, 2008). Nevertheless, even when adhering to these principles, the steady flow of information might lead to a cognitive overload. To avoid this, the recipients must be given more control over transient information. In this respect, a segmentation of information into small, discrete segments has been shown to be beneficial for learning (Hasler, Kersten, & Sweller, 2007; Mayer & Chandler, 2001). However, positive effects of segmentation were qualified by the participants' working memory capacity. Whereas participants with low working memory capacities benefitted from segmentation, participants with high working memory capacities could not improve their performance in recall and transfer when learning with segmented instruction instead of non-segmented instruction (Lusk et al., 2009). Thus, predefined segments are not equally efficient for every learner, because learners with high working memory capacities might not need segmentation. Instead of using predefined segments, learners should be allowed to individually decide when they feel the need to pause the animation to avoid cognitive overload. Findings by Hasler et al. (2007) indicate that merely the possibility to control the flow of transient information in animations with stop and play buttons was as beneficial for learning as having the participants learn with animations divided into predefined segments, even if the respective features were hardly used. Interestingly, giving participants the possibility to change the sequence of instructional information also led to better learning outcomes, even though the possibility to change the sequence was also hardly used (Wouters, Paas, & van Merriënboer, 2010). Thus, giving recipients the opportunity to control pacing of information interactively any time they feel the need might be a promising approach to improve video's potential as a learning tool.

A considerable body of research reviewed by Wetzel, Radtke, and Stern (1994) addressed the usefulness of interactive videos in instructional settings. Overall, Wetzel et al. (1994) concluded that higher levels of interactivity in computer-based video environments were associated with higher levels of achievement. Interactivity in these studies included a broad range of activities such as questioning, giving the participants feedback about their learning progress, and learner control. Investigating the usefulness of questioning and giving feedback, Cennamo, Savenye, and Smith (1991) compared an interactive video, a non-interactive educational video, and a non-interactive video. The interactive video had the learners answer questions actively and gave them feedback

about correct answers. The non-interactive educational video presented the same questions as well as the correct answers during the presentation of the video; however, answering actively was not requested. The non-interactive video did not present any questions. Cennamo et al. (1991) reported a superiority of the interactive video over the non-interactive video concerning the recall of facts, whereas there was no media difference in the amount of mental effort invested by the participants.

Even though the effectiveness of interactive videos has been frequently demonstrated (Fletcher, 1990), most of these studies hardly allow any conclusions about the effectiveness of specific features because they lack detailed information about the implementation of those features (Wetzel et al., 1994).

Given the important role of micro- and macro-level activities in text processing, it can be hypothesized that the inclusion of respective features in videos should lead to improvement of memory and comprehension of the videos' content by establishing learner control. Empirical support for this notion comes from a study that compared the learning effectiveness of interactive videos with that of traditional, non-interactive videos (Schwan & Riempp, 2004). Using the task of learning to tie nautical knots, Schwan and Riempp (2004) could show that learners spontaneously take advantage of the possibility to manipulate the video's pace and sequence of presentation via stopping and browsing, and that this leads to mastering the knots significantly faster. This finding is in line with Zahn, Barquero, and Schwan (2004) who found that the use of basic interactive features in hypervideos was positively related to knowledge on the topic that was learned, and with Hasler et al. (2007) who found the implementation of start and stop buttons in animations to be beneficial for learning. However, in contrast to the reported research on learning with educational films (e.g., Furnham et al., 2002; Walma van der Molen & van der Voort, 2000), Schwan and Riempp (2004) and Hasler et al. (2007) focused on the acquisition of procedural skills/knowledge instead of declarative knowledge (Wouters, Tabbers, & Paas, 2007). Also, the video's interactive features allowed for micro-level activities, but did not support macro-level activities. Therefore, the two studies presented here aim to extend and elaborate the findings of Schwan and Riempp (2004) and Hasler et al. (2007) by applying them to the acquisition of declarative knowledge with interactive videos that allow for either micro-level activities or a combination of micro-level and macro-level activities.

It is well established that effective use of a given medium presupposes corresponding skills among the users. With respect to print, students develop the strategies of *micro-level activity* by the 6th grade (Coté et al., 1998). By this age, they can flexibly and actively adapt their reading process to the cognitive demands of the texts. Efficient strategies of *macro-level activity* are developed between the 3rd and 7th grades, although not by all students (Rouet & Coutelet, 2008). In this developmental process, students start with rather crude browsing strategies, followed by the use of the table of contents and finally the use of an index on the most sophisticated level. This level should be reached by young adulthood (see Yussen et al., 1993). With regard to digital videos, corresponding skills on the micro-level can be assumed, because features such as start/stop and rewind/forward have a long cultural tradition in the home entertainment sector, beginning with tape recorders and VCRs. This is also in line with the findings of Schwan and Riempp (2004) that showed that adult viewers spontaneously used start/stop and forward/rewind without any problems. For features supporting macro-level activities, one could also expect skilled use of these features to locate specific information. However, research with textbooks (Rouet & Coutelet, 2008; Yussen et al., 1993) left unresolved, how these processes can be incorporated in superordinate tasks like gathering information from multiple sections of a medium.

5. Overview of the studies

Although digital videos that include interactive features are widespread, for example in the form of DVDs containing educational movies or in the form of streaming videos over the internet, and although they have fundamentally changed the basic characteristics of films, the impact of specific interactive features on information processing and knowledge acquisition has received only scarce empirical attention so far. The two studies presented here are intended as a contribution to fill this gap.

In Study 1, the information processing activities of 12th and 13th grade students learning with either a common digital video providing support for micro-level activities, an enhanced digital video providing support for both micro-level and macro-level activities, or an illustrated textbook were analyzed on the basis of detailed log-files and video protocols. In order to evaluate whether the findings could be generalized to realistic learning settings, a second quasi-experimental study was conducted, in which students in the 11th and 13th grades were required to prepare a homework assignment either with a common video, with an enhanced video, or with an illustrated textbook. We opted for a maximum parallelization of the two studies to combine the advantages of laboratory and field settings to gain ecologically valid evidence (Study 2) that can be related to process data (Study 1). Therefore, no changes were implemented between the two studies.

5.1. Research questions – hypotheses

Overall, we formulated three hypotheses concerning our research questions about the spontaneous use of the interactive features implemented in the media (Research Question 1) and the relationship between the different media (Research Question 2). As both studies should yield comparable results, the same hypotheses were formulated for both studies.

Concerning the spontaneous use of interactive features implemented in the media (Research Question 1), it was hypothesized that similar to the findings of Schwan and Riempp (2004) for procedural learning, the participants of the present study would spontaneously make use of the possibilities for micro-level activities while working through

the videos in order to acquire declarative knowledge and fulfill the essay task (Hypothesis 1). Because Rouet and Coutelet (2008) as well as Yussen et al. (1993) found spontaneous use of features enabling macro-level activities when participants located information in textbooks, we also expected spontaneous use of the table of contents and the index.

Concerning the relationship of the different media (Research Question 2), we formulated two hypotheses. The first hypothesis about the relationship of the different media is concerned with the effects of different levels of interactivity on learning with videos. Whereas the positive effect of features supporting micro-level interactivity has already been demonstrated by Schwan and Riempp (2004) and Zahn et al. (2004) for videos and by Hasler et al. (2007) for animations, the current studies also address the additional effects of features for macro-level interactivity on learning. Based on findings from empirical studies showing that features, such as an index, support locating information (Yussen et al., 1993) and that locating information efficiently predicts efficient information processing positively (Guthrie, 1988), we hypothesized that the enhanced video, affording features for micro-level activities as well as macro-level activities, should outperform the common video, merely affording features for micro-level activities (Hypothesis 2).

The second hypothesis about the relationship of the different media is concerned with the relation of the illustrated textbook condition to the two video conditions. Because the illustrated textbook afforded features for micro-level and macro-level activities and was thus functionally equivalent to the enhanced video, it should be comparable to the enhanced video and outperform the common video (Hypothesis 3). Hence, interactivity was regarded as the main reason for differences between the media, whereas the influence of dynamic presentation of information, multimedia effects, and modality effects (Mayer, 2001; Sweller et al., 1998) was ruled out for various reasons. First, dynamic visual presentation is said to be especially beneficial for learning dynamic processes (see Bétrancourt & Tversky, 2000; Rieber & Kini, 1991). As our materials, on the other hand, required declarative learning rather than procedural learning, we did not assume any positive effect of the dynamic nature of videos. Second, multimedia effects would predict the superiority of text plus pictures over text alone (Mayer, 2001). In particular, the dual-coding theory supports this expectation. This theory assumes that verbal and pictorial codes are processed in two functionally independent but interconnected channels and integrated in a subsequent step (Paivio, 1969, 1971). When the verbal and the pictorial contents are complementary and overlap, they serve as mutual retrieval cues, which in turn enhance recall performance. However, the assumption of a multimedia effect in our study is critical as our textbook was illustrated with central screenshots from the video. Third, the modality principle would predict the superiority of pictures plus spoken text over pictures plus written text. However, recent research has revealed that modality effects only occur when short texts accompany the pictures (transitory information effect; Leahy & Sweller, 2011). Thus, we did not expect a modality effect because the text in our study was rather long.

6. Study 1

The goal of the first study was to analyze the patterns of learning activities that occur with two different types of digital interactive videos and to compare them to the respective patterns that occurred using an illustrated textbook. The two types of videos differed with respect to the activities they allowed for. The *common video* provided features that are typical for the present state of digital videos, including start/stop and forward/rewind, and thus allowed the learners to engage in micro-level activities for processing its contents. In contrast, besides support for micro-level activities, the *enhanced video* additionally included an interactive table of contents and an interactive index, thus providing opportunities for macro-level activities as well. By using the history of Germany from 1945 to 1950 as a content domain, participants were given the task of working through the video or text, respectively, in order to write three short essays. During the task, the participants were videotaped. Also, in the two video conditions, the actions of the users were recorded in log-files.

6.1. Method

6.1.1. Participants and design

Sixty students (31 female, 29 male) from the 12th and 13th grades of German secondary schools participated in the study. They received €24 for participation. The students' age averaged at 18.20 years (SD = 0.78). Twenty students were randomly assigned to each of the experimental conditions representing the three levels of the between-subjects factor medium (*common video* vs. *enhanced video* vs. *illustrated textbook*).

6.1.2. Materials

6.1.2.1. Types of media. The original film used in the reported studies was an educational film about the political and economic situation in post-war Germany after World War II (FWU, 2003). The film lasted 16 min and 24 s and compared the US-American, British, French, and Soviet zones of occupation as well as the implementation of the Potsdam Treaty in these zones, finally leading to the division of Germany into two different countries. The film was divided into ten chapters using mainly original audiovisual documents with a voice-over commentary. Additionally, animated maps were used to illustrate the change of Germany's borders over the years. In general, there was a high overlap of verbal and pictorial information. The film was recommended for education in the 8th to 13th grades and for adult education. Therefore, its contents can be considered to be rather complex.

Based on this original film, we created three different types of media: a *common video*, an *enhanced video* and an *illustrated textbook*. Fig. 1 gives an overview of the different media.

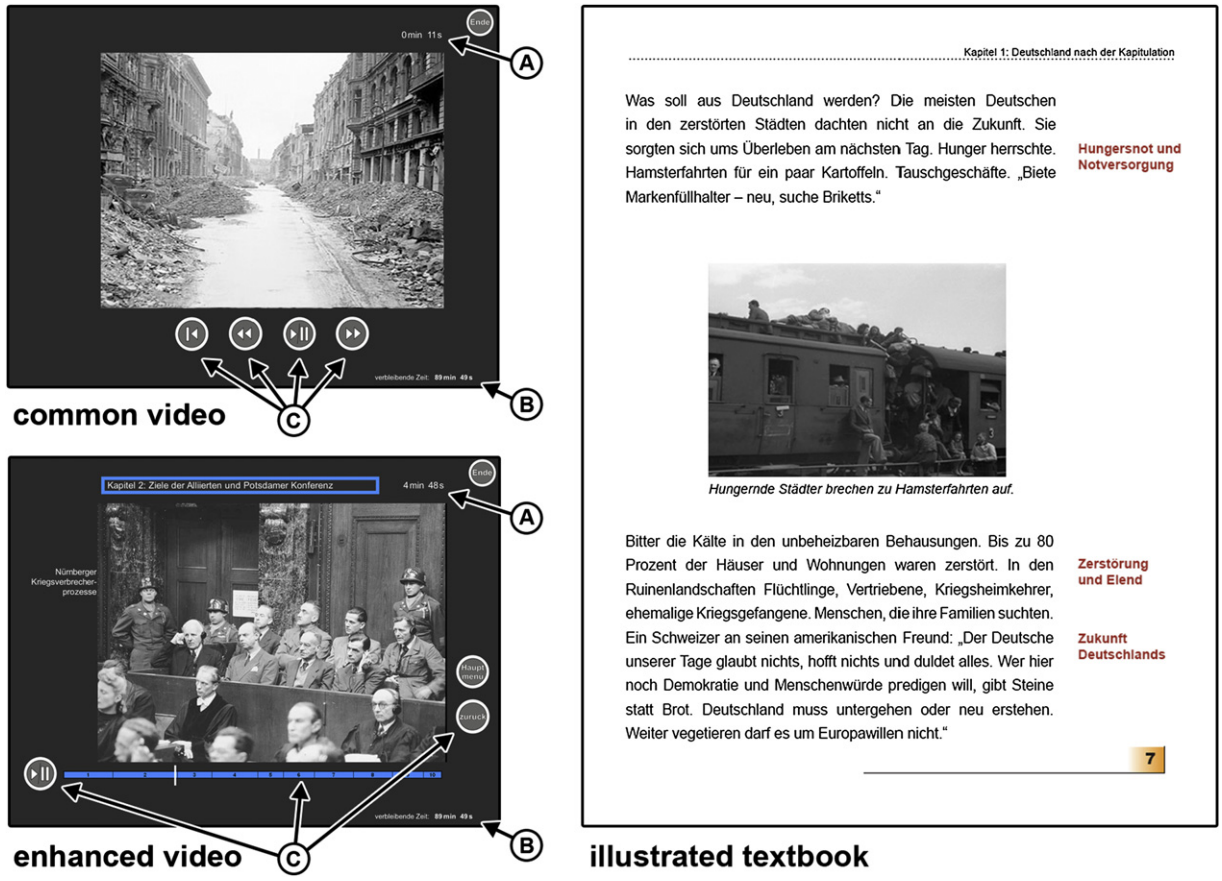

Fig. 1. An overview of the three different types of media: common video, enhanced video, illustrated textbook. Notes: A = video running time, B = time left to work with the video, C = interactive features. The pictures in this figure were taken from Deutsches Bundesarchiv, IWMCollections, and National Archives and Records Administration.

The *common video* offered its users a range of interactive features allowing for micro-level activities. Analogous to the features of a regular VHS tape, a start-/stop-, a forward and a rewind button were implemented in the video. The time for working with the video was limited to 90 min. The common video included indicators for the time left to work and the video running time.

The *enhanced video* offered its users a range of interactive features that supported both micro-level as well as macro-level activities. This included a start-/stop-button, and a timeline that the user could navigate via a slider. The timeline was divided into ten sections representing the chapters of the video that could be chosen by clicking the respective section on the timeline. In addition, the users could also navigate through the video via a table of contents and an index that were both available via a main menu. The table of contents listed the ten chapters of the video in chronological order; the index listed the central key terms in alphabetical order. While the video was playing, the chapter name and chapter number were shown above the video and the central key terms were shown on the left of the video. We also implemented indicators for the time left to work (time limit: 90 min) and the video running time.

The third medium was an *illustrated textbook* (46 pages), which served as a printed control condition. To achieve maximum comparability of the contents of the different media, several measures were taken. First, the *illustrated textbook* consisted of a literal transcription of the video's audio trace. This procedure is in line with the efforts of previous media comparisons to establish content-equivalence of the media (e.g., Furnham et al., 2002; Walma van der Molen & van der Voort, 2000). Second, the text was illustrated with a set of 42 screenshots from the video. The selection of the appropriate screenshots was based on the choices made by ten independent raters who rated the screenshots for being representative of the video's content. Third, the illustrated textbook was fitted with features equivalent to the enhanced video, establishing both micro-level as well as macro-level activities. It contained a table of contents and an index. The chapter name and chapter number were printed on top of the pages; the central key terms were printed to the right of the text. The same labels for chapters, the index, and central key terms as in the enhanced video were used.

6.1.3. Measures

6.1.3.1. History-related interest and self-concept. History-related interest was assessed using an adaption of a procedure developed by Sparfeldt, Rost, and Schilling (2004). On a scale from 1 (very low) to 6 (very high), the participants were asked to indicate their agreement to eight statements about their interest in history. The items were averaged to obtain an

overall value for history-related interest. Sample items are "I could imagine studying history." or "After a long weekend or holiday, I look forward to history classes.". Sparfeldt et al. (2004) report an α between 0.93 and 0.94 for the subjects mathematics, German, physics, and English

To assess the participants' history-related self-concept, we used the DISC-Grid (Differential Self-Concept-Grid; Rost & Sparfeldt, 2002). On a scale from 1 (very low) to 6 (very high), participants had to indicate their agreement to eight statements concerning their self-concept in history. The items were averaged to get an overall value for history-related self-concept. Sample items for this scale are "It's easy to have good grades in history." or "For me, it's easy to solve problems in history." Rost and Sparfeldt (2002) report an α of 0.94 for this scale.

6.1.3.2. Reading strategies. We assessed reading strategies to control for individual differences in this respect. For this purpose, we used the Würzburger-Lesestrategie-Wissenstest für die Klassen 7–12 (WLST 7–12; Test of Reading Strategies for Grades 7–12; Schlagmüller & Schneider, 2007). The WLST 7–12 is a scenario-based procedure that tests for appropriate reading strategies for understanding texts. During this procedure, the students do not actively engage in a reading task. Instead, they rate several solutions for six reading scenarios that include appropriate strategies for understanding texts as well as for handling unfamiliar words. For each scenario, five to seven solutions are rated on a 6-point scale from 1 (very good) to 6 (insufficient). Thereby, the same ratings can be given for several solutions. The final score of the WLST 7–12 is calculated by multiple pairwise comparisons of the participants' ratings of the solutions to the reading scenarios. Participants could achieve a maximum of 80 points in this procedure. An α of 0.88 is reported in the test's manual. Since we used the WLST 7–12 to identify differences between our experimental conditions instead of using the norms of the procedure to classify participants as good or poor readers, the use of this procedure in grade 13 can be considered unproblematic.

6.1.3.3. Media experience. For the assessment of the participants' media experience, participants filled in seven items asking for the frequency of their usage of different media such as video, DVD or computers. The participants gave their answers on a 5-point scale with the labels nearly everyday, several times a week, between once a week and once a month, less than once a month, and never. The items were coded so that 0 marked the minimum (never) and 4 marked the maximum (nearly everyday). However, an α of 0.38 in the two reported studies has to be considered very low, not to say unacceptable.

6.1.3.4. Prior knowledge. To assess prior knowledge, the students completed a test covering events from recent and most recent history. In this test, they were asked to assign 24 events to one of ten 25-year time slots between 1750 and 1999. Participants received 1 point for each correctly placed event, so that a maximum of 24 points was possible. We chose to assess prior knowledge that goes far beyond the time span of our experimental materials in order to avoid priming of selective information processing. The prior knowledge test contained events that are a part of local school curricula (e.g. the declaration of human rights in France) as well as events that are closely related to our learning materials (e.g. the foundation of the German Democratic Republic). Hence, the scores in the prior knowledge test should reflect the participants' relevant knowledge about history. In a preliminary study with 21 student participants from a German university (average age = 20.71, *SD* = 1.59), α for the final test version was 0.84.

6.1.3.5. Usage patterns. In the two video conditions, we recorded log-files to obtain an insight into the students' usage patterns. The log-files revealed information about the frequency of use of the interactive features.

For the common video, browsing was measured by the frequency of the use of forward and rewind. The count for browsing was raised by 1 each time either one of the two features was pushed, held and released. The count for the use of stop was raised by 1 each time the feature was used.

For the enhanced video, browsing was operationalized through the frequency of the use of the slider. The count for browsing was raised by 1 each instance the slider was moved and released. The count for table of contents was raised by 1 each time a chapter was selected via the table of contents or via the slider bar. The count for index was raised by 1 each instance an item was selected in the index. The count for the use of stop was raised by 1 each time this feature was used.

To obtain analogous data for the illustrated textbook condition, all participants were videotaped with two cameras while working with the medium. Two independent raters rated the video recordings for use of browsing, table of contents, and index. The count for browsing was raised by 1 each time a person browsed through at least two pages in a row. The count for the use of the table of contents was raised by 1 each time the participants consulted the table of contents and showed clear signs of searching in the book afterward. The count for the use of the index was raised by 1 each time the participants referred to the index and showed clear signs of searching in the book afterward. This method was chosen to maximize comparability with the enhanced video. In the enhanced video condition, the count for table of contents and for index was only raised by 1 when a chapter or an item in the index was actually selected.

6.1.3.6. Knowledge acquisition. Knowledge acquisition was assessed in two ways: via a multiple choice test after working with the medium and via three essays that were written while working with the medium. Whereas the multiple choice test reflected retention, the essays served as indicators for the participants' efficiency in extracting relevant knowledge from the media.

The *multiple choice test* consisted of 15 items with five alternative answers each. The test items were derived from the

verbal contents of the media as well as from the information presented in the maps. For all items, one to three answers were correct. Participants received 1 point for selecting correct answers and 1 point for not selecting false answers. Thus, a maximum of 75 points was attainable. Please refer to Table 1 for a sample item. In a preliminary study with 21 student participants from a German university (average age = 20.71, $SD = 1.59$), α for the final test version was 0.71.

In the process of working with the media, the participants had to accomplish *three open-ended essay tasks*. These tasks were selected after a comprehensive consultation of several books intended to prepare students for their final exams (Frielingsdorf, 2004; Wilmes, 1997) and were thus compatible with local standards for history education (Ministerium für Jugend, Kultus und Sport Baden-Württemberg, 2004). In the essays, the participants were asked to (1) describe the situation in Post-War Germany, (2) describe how the Potsdam Treaty was implemented in the different occupation zones and (3) appraise whether the division of Germany was predictable from the events between 1945 and 1949. Each essay covered multiple chapters of the medium. Whereas Essay 1 and 2 required the participants to collect information from the medium, Essay 3 additionally required the participants' inferences. To quantify the data, a coding scheme was developed from expert answers offered in the books that were consulted.

The coding scheme contained all the facts that could have been gathered from the ten different chapters of the medium to answer the essay tasks. Each fact was represented by a unique code that could be ascribed to the participants' essays. Each code was only considered once per essay. The number of unique codes was 33, 48 and 53 for Essay 1, 2 and 3, respectively. It was not expected that the participants mention all the facts that could have potentially been coded. All the codes were weighted equally.

To obtain the participants' values for the number of facts, the codes were counted for each essay and then summed up for the final score. To obtain the participants' values for the distribution of facts, the chapters from which the facts were retrieved were counted. Each chapter was only considered once per essay; however, chapters could be considered multiple times when the scores for the individual essays were summed up and divided by three to arrive at the final score for the distribution of facts across the medium.

Table 1
One sample item from the multiple choice knowledge test. Correct answers are printed in bold letters.

Which of the statements about the Potsdam Conference and the Potsdam Treaty regulating the treatment of the defeated Third Reich are correct?
France's exit of the Allied Control Council was sealed.
The Allies established that Germany should be regarded as one economic unit during the time of occupation.
Germany should be maintained as a unitary state and not be divided into independent states.
The decision to prosecute the main men in charge of the war was commonly implemented by the Allies.
Great Britain did not participate in the Potsdam Conference.

The coding schemes were verified and modified by two independent raters during the first coding trials. Raters used Microsoft Word to assign codes to the essays. The inter-rater-correlations were 0.91 for number of facts and 0.77 for distribution of facts, both $p < .001$. Disagreements were resolved by discussion.

6.1.3.7. Subjective appraisal of the learning process with the medium. Paechter, Maier, and Grabensberger (2007) developed a questionnaire to assess an individual's appraisal of learning processes with media. We adapted several items of this questionnaire for our purpose. Six items ($\alpha = .67$ for the two reported studies) assessed media-supported expertise acquisition in the knowledge domain (e.g., "I think the interactive video supports individual learning processes.") and five items ($\alpha = .84$ for the two reported studies) assessed expertise acquisition in using the medium (e.g., "I think I have learned something about interactive media".). The participants rated the items on a 5-point scale from 1 (fully agree) to 5 (fully disagree).

6.1.4. Procedure

The experiment took place in our research lab. After the participants' arrival, demographic data, media experience, history-related interest and self-concept as well as prior knowledge were assessed. After an introduction of the different media, the participants in the video conditions had the opportunity to practice the use of the respective interactive features (time limit: 8 min) without any guidance offered by the experimenter. The video used for practice was not related in content to the experimental video. After the introduction to the different media, the participants were given the common video, the enhanced video, or the illustrated textbook for a maximum of 90 min. While working with the medium, the participants had to write three essays covering the transmitted contents. Participants in all conditions received a written source document about the Potsdam Treaty that provided them with additional information while writing the essays (taken from Frielingsdorf, 2004). After working with the medium, the participants were given a multiple choice test to assess their knowledge of media content and a test to assess reading strategies (WLST 7–12). Further, students were asked for an appraisal of their learning processes with the medium. The entire experiment took about 3 h.

6.2. Results

All post-hoc comparisons reported in the subsequent section were Bonferroni-adjusted.

6.2.1. Control variables

The students in the different conditions did not differ as regards to history-related interest, $F < 1$, and self-concept, $F(2,57) = 2.37$, $p = .103$, $\eta_p^2 = .08$, prior knowledge, $F < 1$, and media experience, $F < 1$. However, there was a marginal effect of reading strategies, $F(2,53) = 3.07$, $p = .055$, $\eta_p^2 = .10$. Because reading strategies did not

Table 2
Means (with standard deviations in parentheses) for the control variables.

Medium	History-related interest	History-related self-concept	Prior knowledge	Reading strategies	Media experience
Common video	3.43 (0.90)	3.80 (0.78)	9.90 (3.78)	71.79 (4.37)	1.91 (0.34)
Enhanced video	3.77 (0.99)	4.29 (0.85)	10.65 (4.79)	68.75 (5.39)	1.96 (0.41)
Illustrated textbook	3.41 (1.16)	3.72 (1.04)	10.50 (5.56)	67.06 (7.55)	1.98 (0.42)
Total	3.54 (1.02)	3.94 (0.92)	10.35 (4.70)	69.27 (6.05)	1.95 (0.39)

correlate with any of the dependent variables, all $ps > 0.127$, we did not include reading strategies as a covariate in the analyses. Degrees of freedom vary, because we have excluded the values of four participants performing at least three standard deviations below mean from the analysis for reading strategies. Please see Table 2 for descriptive data.

6.2.2. Usage patterns

Table 3 shows that the participants in the common video condition made extensive use of its features supporting micro-level activities. While working through the video, they regulated their viewing pace by means of the stop-button ($M = 33.65$, $SD = 17.35$) and also browsed through the video by means of the forward/rewind buttons ($M = 17.90$; $SD = 9.77$). Similarly, the participants in the enhanced video condition also made use of its micro-level interactive features. Again, they made use of the stop-button ($M = 17.20$, $SD = 15.01$) as well as of the slider that allowed for browsing ($M = 10.20$, $SD = 7.11$). Nevertheless, a 2 × 2 ANOVA comparison of the enhanced video and the common video with regard to browsing and stopping revealed a main effect of medium, $F(1,38) = 11.23$, $p = .002$, $\eta_p^2 = .23$, showing that these features were used significantly more often in the common video condition ($M = 51.55$, $SD = 24.93$) than in the enhanced video condition ($M = 27.40$, $SD = 20.43$). The lower frequency of micro-level activities in the enhanced video condition can be attributed possibly to the additional use of the macro-level features, in particular the table of contents ($M = 6.95$, $SD = 4.24$) and the index ($M = 1.90$, $SD = 3.57$). In other words, the participants in the enhanced video condition spontaneously used both its micro-level and macro-level features to work through the video, albeit the latter to a lesser extent. Additionally, there was a main effect of type of interactive feature, $F(1,38) = 33.81$, $p < .001$, $\eta_p^2 = .47$, with stopping ($M = 25.43$, $SD = 18.05$) being more frequently used than browsing ($M = 14.05$, $SD = 9.29$). This highlights the participants' need to control the pace of the information flow, which is a problem that is particularly relevant for transient, dynamic media presentations (Chandler, 2004; Mayer & Chandler, 2001). There was also a significant interaction between the factors medium and feature, $F(1,38) = 5.00$, $p = .031$, $\eta_p^2 = .12$. Even though both the stop and browsing features were used significantly more often in the common video than in the enhanced video (stop: $p = .003$; browsing: $p = .007$), the difference for the use of the stop-button between the two media (common video: $M = 33.65$, $SD = 17.35$; enhanced video: $M = 17.20$, $SD = 15.01$) was larger than the difference for the use of the respective browsing features between the two media (common video: $M = 17.90$, $SD = 9.77$; enhanced video: $M = 10.20$, $SD = 7.11$).

Table 3
Means (with standard deviations in parentheses) for the frequency of use for the features of the media.

Medium	Feature			
	Micro-level activities		Macro-level activities	
	Stop	Browsing	Table of contents	Index
Common video	33.65 (17.35)	17.90 (9.77)	–	–
Enhanced video	17.20 (15.01)	10.20 (7.11)	6.95 (4.24)	1.90 (3.57)
Illustrated textbook	–	7.80 (4.24)	0.38 (0.72)	0.08 (0.24)

In order to determine the frequency of comparable activities for the illustrated textbook condition, the video recordings of the learners' behavior were analyzed by two independent raters. The correlations of the independent ratings were 0.72 ($p < .001$), 0.78 ($p < .001$), and 0.69 ($p = .001$) for the use of browsing, table of contents and index, respectively. With regard to micro-level activities, the frequency of flipping through pages was determined as an indicator of browsing. Page flipping occurred with a mean of 7.80 ($SD = 4.24$), whereby it should be kept in mind that the comparability of the illustrated textbook and the two video conditions is limited, as browsing in the video conditions also included browsing within a page whereas this was not the case for the illustrated textbook. Without using eye-tracking methods, there is no way to assess browsing within a page when reading printed texts in a textbook format. As a result, the count for browsing in the textbook condition is underestimated in comparison to the count of browsing in the two video conditions. Further, both the use of table of contents and of index was determined for the illustrated textbook, which was both extremely low ($M = 0.38$, $SD = 0.72$ for table of contents; $M = 0.08$, $SD = 0.24$ for index). A 2 × 3 (Medium [illustrated textbook, enhanced video] × Feature [browsing, table of contents, index])-factorial ANOVA with feature as a within-subjects factor was calculated. As the sphericity assumption was violated in this ANOVA, the Greenhouse–Geisser corrected values are reported. There was a main effect of feature, $F(1.69,64.06) = 42.69$, $p < .001$, $\eta_p^2 = .53$. Post-hoc analyses revealed that browsing ($M = 9.00$, $SD = 5.91$) was used more often than the table of contents ($M = 3.66$, $SD = 4.48$), $p < .001$, which in turn was used more often than the index ($M = 0.99$, $SD = 2.66$), $p = .001$. There also was a significant main effect for medium, $F(1,38) = 20.77$, $p < .001$, $\eta_p^2 = .35$. The features of the enhanced video ($M = 19.05$. $SD = 9.72$) were used more often than the respective features of the illustrated textbook ($M = 8.25$, $SD = 4.22$). This pattern was qualified by an interaction of the two factors, $F(1.69,64.06) = 4.31$, $p = .023$, $\eta_p^2 = .10$. Whereas there were no differences for the use frequency of browsing between the

enhanced video and the illustrated textbook, $p = .203$, there were significant media differences for the use frequency of the table of contents, $p < .001$, and the index, $p = .028$, with the respective features being used more often in the enhanced video condition. Please refer to Table 3 for descriptive data.

6.2.3. Knowledge acquisition

Table 4 gives an overview of the descriptive data for the knowledge acquisition measures. Regarding the multiple choice knowledge test, a one-factorial ANOVA with the three-leveled factor medium revealed no main effect for the factor medium, $F < 1$. The overall achievement on this measure was 57.80 ($SD = 5.38$; maximum: 75) and can be considered slightly above average.

The essays were coded for number of facts and for distribution of facts across the medium by two independent raters. For number of facts, a one-factorial ANOVA with the three-leveled factor medium yielded no significant main effect, $F < 1$. In general, the overall number of facts mentioned was 26.53 ($SD = 7.03$). For the distribution of facts across the medium, a significant main effect for medium was found, $F(2,57) = 4.82$, $p = .012$, $\eta_p^2 = .15$. The users of the common video ($M = 3.93$, $SD = 0.50$) reported facts from significantly more chapters than the users of the enhanced video ($M = 3.28$, $SD = 0.74$), $p = .009$. The illustrated textbook ($M = 3.63$, $SD = 0.73$) and the common video, $p = .474$, as well as the illustrated textbook and the enhanced video, $p = .301$, did not differ.

6.2.4. Subjective appraisal of the learning process with the medium

Two one-factorial ANOVAs with the three-leveled factor medium revealed no significant differences in the students' appraisal of the media with regard to expertise acquisition in the knowledge domain ($M = 2.52$, $SD = 0.65$), $F < 1$, and expertise acquisition in using the medium ($M = 2.63$, $SD = 0.82$), $F < 1$. Descriptively, both values can be considered average.

6.3. Discussion

In line with the first hypothesis, the results of Study 1 demonstrate that the participants actively controlled the media presentations by utilizing the various interactive features provided by the two video versions (Hypothesis 1). This was true on the local level of the videos, where start/stop and forward/rewind were used to adapt the pace of presentation to the momentary cognitive needs as well as for reviewing and looking back within the video material. Such micro-level activities were observed both for the common video and the enhanced video. Additionally, participants in the enhanced video condition also used the table of contents and the index for navigating throughout the video, albeit these features were used to a lesser extent than the features enabling micro-level activities. This observation reflects the developmental steps identified by Rouet and Coutelet (2008) that describe how students first start with crude strategies of browsing before they develop skills in the usage of text organizers to search for information within a medium. As a consequence, it could be argued that the students relied more frequently on features supporting less sophisticated strategies when searching for information. This tendency was pronouncedly stronger for the illustrated textbook, as the students relied mostly on micro-level activities for processing the text contents and hardly used the features for macro-level activities at all.

Even though the table of contents and the index were used, they did not lead to the superiority of the enhanced video or the illustrated textbook over the common video. Contrary to Hypothesis 2, the common video affording micro-level interactivity led to a broader distribution of the mentioned facts across the medium than the enhanced video affording micro-level and macro-level interactivity. We also failed to verify Hypothesis 3, as the illustrated textbook did not outperform the common video. However, as expected, the illustrated textbook and the enhanced video led to comparable outcomes. These observations indicate that the use of the table of contents and the index could not be incorporated into suitable strategies for gathering comprehensive information from different sections of the media. Thus, watching the video or reading the book in a linear fashion and using the stop- and browsing-features to control the flow of the information might have been a superior strategy for processing the media as missing or neglecting information could be prevented. This assumption is supported by the finding that the common video, where these two features were used significantly more frequently, outperformed the enhanced video concerning the distribution of facts across the medium, reflecting broader and more comprehensive navigation through the medium.

Because we regard Study 1 and Study 2 as complementary, further interpretations as well as implications of these results for future research will be given in the General discussion.

7. Study 2

One could argue that certain characteristics of the experimental situation in Study 1 may have biased the participants to make extensive use of the videos' interactive features. In particular, the study took place in a laboratory setting and may

Table 4
Means (with standard deviations in parentheses) for the measures of knowledge acquisition and the subjective appraisal of the learning process with the medium.

Medium	Multiple choice knowledge test	Number of facts	Distribution of facts	Appraisal: expertise in the knowledge domain	Appraisal: expertise in using the medium
Common video	57.75 (4.70)	27.95 (5.83)	3.93 (0.50)	2.43 (0.39)	2.58 (0.80)
Enhanced video	57.05 (5.59)	25.25 (8.91)	3.28 (0.74)	2.54 (0.90)	2.81 (0.98)
Illustrated textbook	58.60 (5.93)	26.40 (6.03)	3.63 (0.73)	2.58 (0.59)	2.51 (0.66)
Total	57.80 (5.38)	26.53 (7.03)	3.62 (0.71)	2.52 (0.65)	2.63 (0.82)

therefore have induced high-demand characteristics. The situation in a laboratory is different from the situation the students face at home because the students in the laboratory are shielded from external interferences and distractions that might challenge mastering a homework assignment in the real world. Because the students were videotaped in the laboratory study, they may have invested more effort than they would have in a realistic setting not being observed. Conducting the study in our lab during the students' leisure time may have additionally led to a selection bias in favor of highly motivated students taking part in the laboratory study. These differences between the field and the laboratory study may reduce the generalizability of our findings in the laboratory to real world learning experiences. Thus, the question arises whether students would also benefit from the interactive features of videos under realistic conditions at school, when entire classes became the sample.

Therefore, in a quasi-experimental field study, we wanted to test whether the findings of Study 1 would also be observed in a regular classroom setting, increasing the external validity of our research. We chose a homework assignment of writing three essays (similar to Study 1) as a means to investigate the students' work with the different media (common video, enhanced video, illustrated textbook). It was expected that the demand characteristics of an everyday homework situation would be substantially lower than in the laboratory setting of Study 1. In particular, many students have negative feelings about homework, probably resulting in as little time and effort spent on homework assignments as possible. Additionally, time and effort spent on homework might be considered lost time and effort for other, more pleasant activities (also see Warton, 2001). Thus, the tendency to ignore sections of the medium when the table of contents and index are present should even increase in the field study, leading to a similar but even more pronounced pattern of differences between the media conditions.

7.1. Method

7.1.1. Participants and design

Twelve German history classes from the 11th and the 13th grade of German secondary schools participated in the study. The students chose to participate and were not compensated for their efforts. Altogether, data of 156 (107 female, 49 male) students were used. The students' age averaged 17.31 years ($SD = 1.03$). Six classes were 11th grade (97 students) and six classes were 13th grade (59 students). Classes within each grade level were randomly assigned to the experimental conditions representing the three levels of the between-subjects factor medium (*common video* vs. *enhanced video* vs. *illustrated textbook*). Because grade level is treated as an independent variable for methodological reasons, the design can be considered 2 × 3-factorial with the factors *grade level* and *medium*. To control classroom effects statistically, *class* was included as a nested factor in the respective analyses. Please refer to Table 5 or 6 for the distribution of the participants (N) over the experimental conditions.

7.1.2. Materials and measures

To maximize comparability of Studies 1 and 2, we used the same materials and measures in both studies with the exception of log-files and video recordings, which could not be implemented in the context of a homework assignment. Comparable to the procedure described in Section 6.1.3., the essays written in Study 2 were coded by two independent raters. Inter-rater-correlations were 0.96 for number of facts and 0.83 for distribution of facts across the medium, both $p < .001$. Disagreements were resolved by discussion. With regard to the other measures, please refer to Sections 6.1.2. and 6.1.3 for further details.

7.1.3. Procedure

Study 2 took place in twelve German history classrooms. The study comprised two history lessons (45 min each) and a homework assignment. In the first lesson, demographic data, media experience, history-related interest and self-concept, and prior knowledge were assessed as control variables. Next, the students were handed the essay instructions as well as the written source document about the Potsdam Treaty (taken from Frielingsdorf, 2004) as a homework assignment. The video groups were granted access to the video environments via the schools' computer networks. Two classes received DVDs with the video environment, as their school's computers did not match the software's system requirements.

Table 5
Means (with standard deviations in parentheses) for the control variables.

Medium	Grade level	N	History-related interest	History-related self-concept	Prior knowledge	Reading strategies	Media experience	Delay
Common video	11	34	3.59 (1.06)	3.74 (1.05)	10.82 (4.97)	62.71 (9.04)	2.02 (0.33)	2.44 (1.33)
	13	22	3.05 (1.12)	3.37 (1.05)	11.50 (5.83)	65.91 (7.00)	1.86 (0.33)	2.29 (1.49)
	Total	56	3.38 (1.11)	3.59 (1.06)	11.09 (5.28)	63.96(8.38)	1.96 (0.34)	2.38 (1.38)
Enhanced video	11	26	3.63 (1.34)	3.51 (1.05)	9.15 (4.64)	63.96(7.38)	2.06 (0.35)	3.15 (1.74)
	13	12	3.30 (1.24)	3.47 (1.27)	12.67 (5.02)	68.00 (8.75)	2.05 (0.24)	3.33 (2.39)
	Total	38	3.52 (1.30)	3.50 (1.11)	10.26 (4.97)	65.24 (7.95)	2.06 (0.31)	3.21 (1.93)
Illustrated textbook	11	37	3.30 (1.33)	3.67 (1.26)	8.22 (4.01)	59.78 (13.75)	1.97 (0.31)	2.09 (1.65)
	13	25	2.77 (1.23)	3.30 (1.16)	10.68 (3.66)	65.20 (6.46)	1.83 (0.40)	2.63 (1.81)
	Total	62	3.08 (1.31)	3.52 (1.22)	11.17(3.69)	63.92 (6.13)	1.92 (0.36)	2.36 (1.74)
Total	11	97	3.49 (1.24)	3.65 (1.13)	9.38 (4.63)	61.93 (10.78)	2.01 (0.33)	2.57 (1.59)
	13	59	2.98 (1.19)	3.36 (1.12)	11.39 (4.81)	66.03 (7.12)	1.89 (0.35)	2.65 (1.85)
	Total	156	3.30 (1.24)	3.54 (1.13)	10.14 (4.78)	63.48 (9.75)	1.97 (0.34)	2.60 (1.70)

The illustrated textbooks were handed out to the students. The students were given one week to finish the homework assignment. After this week, the second lesson took place. The students filled in a multiple choice knowledge test about the contents of the media and the WLST 7-12 to assess their reading strategies. Finally, they were asked for an appraisal of their learning processes with the medium. In this context, the students reported the delay between the time they finished the homework assignment and the second lesson.

7.2. Results

Because the participants were randomly assigned to the conditions on class level, the factor class was included in the analyses as a nested factor to control its statistical impact. Following the recommendations of Winer (1971) and Crits-Christoph and Mintz (1991), the factor class was excluded from the analyses as a nuisance factor when $p > .20$. All post-hoc comparisons reported in the subsequent section were Bonferroni-adjusted.

7.2.1. Control variables

The descriptive data for the control variables can be found in Table 5. For *history-related interest*, a 2 × 3 (Grade Level [11, 13] × Medium [common video, enhanced video, illustrated textbook]) −factorial nested ANOVA with class as a nested factor revealed no main effect of class, $F(6,144) = 1.31$, $p = .256$, $\eta_p^2 = .05$. Therefore, class was excluded from further analysis. A subsequent 2 × 3-factorial ANOVA revealed a main effect for grade level, $F(1,150) = 4.93$, $p = .028$, $\eta_p^2 = .03$. Students in the 11th grade ($M = 3.49$, $SD = 1.24$) were more interested in history than students in the 13th grade ($M = 2.98$, $SD = 1.19$). There was no main effect for medium, $F(2,150) = 1.50$, $p = .226$, $\eta_p^2 = .02$, and no interaction of grade level and medium, $F < 1$. Overall ($M = 3.30$, $SD = 1.24$), history-related interest can be considered average. Because history-related interest correlated with the results of the multiple choice knowledge test, $r = 0.22$, $p = .006$, it was included in the respective analysis as a covariate.

For *history-related self-concept*, a 2 × 3-factorial nested ANOVA with class as a nested factor revealed no main effect of class, $F < 1$. Therefore, class was excluded as a factor from further analysis. A subsequent 2 × 3-factorial ANOVA revealed no main effects for grade level, $F(1,150) = 1.79$, $p = .184$, $\eta_p^2 = .01$, and medium, $F < 1$, and no interaction of the two factors, $F < 1$. Overall, history-related self-concept could be considered average ($M = 3.54$, $SD = 1.13$).

For *delay between homework completion and the second lesson*, a 2 × 3-factorial nested ANOVA with class as a nested factor revealed a main effect of class, $F(5,129) = 1.59$, $p = .167$, $\eta_p^2 = .06$. There was no main effect for medium, $F(2,4.77) = 1.69$, $p = .278$, $\eta_p^2 = .42$, or grade level, $F < 1$, and no interaction of the two factors, $F < 1$. The observed mean delay was 2.60 days ($SD = 1.07$). Because delay correlated with the appraisal of the medium as regards to expertise acquisition in using the medium, $r = -0.18$, $p = .029$, it was included in the respective analysis as a covariate. Degrees of freedom for delay differ from other variables, because some students did not fill in the item asking for delay.

For *prior knowledge*, a 2 × 3-factorial nested ANOVA with class as a nested factor revealed class differences, $F(6,144) = 2.61$, $p = .020$, $\eta_p^2 = .10$. There was no main effect for medium, $F < 1$, or grade level, $F(1,6.67) = 2.50$, $p = .160$, $\eta_p^2 = .27$, and no interaction of the two factors, $F < 1$. Regarding a maximum of 24 available points, overall prior knowledge of the students could be considered average ($M = 10.14$, $SD = 4.78$). Because prior knowledge correlated with the results of the multiple choice test, $r = 0.41$, $p < .001$, and the distribution of facts across the medium, $r = 0.17$, $p = .031$, it was included in the respective analyses as a covariate.

For *reading strategies*, a 2 × 3-factorial nested ANOVA with class as a nested factor revealed a main effect of class, $F(6,144) = 3.22$, $p = .005$, $\eta_p^2 = .12$. There was no main effect for medium, $F < 1$, or grade level, $F(1,6.54) = 3.23$, $p = .118$, $\eta_p^2 = .33$, and no interaction of the two factors, $F < 1$. With an overall value of 63.48 ($SD = 9.75$), the students' knowledge of reading strategies could be considered high (maximum: 80). Because reading strategies correlated with the number of facts named, $r = 0.25$, $p = .002$, and the distribution of facts across the medium, $r = 0.26$, $p = .001$, it was included in the respective analyses as a covariate.

For *media experience*, a 2 × 3-factorial nested ANOVA with class as a nested factor revealed no main effect of class, $F < 1$. Therefore, class was excluded from further analysis. A subsequent 2 × 3-factorial ANOVA revealed no main effects for medium, $F(2,150) = 2.16$, $p = .119$, $\eta_p^2 = .03$, and no interaction of the two factors, $F < 1$. There was a marginal effect for grade level, $F(1,150) = 3.21$, $p = .075$, $\eta_p^2 = .02$, with the students in 11th grade ($M = 2.01$, $SD = 0.33$) reporting more media experience than the students in 13th grade ($M = 1.89$, $SD = 0.35$). The students' overall media experience could be considered average ($M = 1.97$; $SD = 0.34$). Because media experience was negatively correlated with the results of the multiple choice test, $r = -0.16$, $p = .046$, it was included in the respective analysis as a covariate.

7.2.2. Knowledge acquisition

Table 6 summarizes the descriptive data for the knowledge acquisition measures. For the multiple choice knowledge test, a 2 × 3-factorial nested ANCOVA with class as a nested factor and prior knowledge, history-related interest and media experience as covariates revealed significant differences between the classes within the conditions, $F(6,141) = 2.76$, $p = .015$, $\eta_p^2 = .11$. There were no significant main effects for grade level, $F < 1$, and medium, $F(2,6.46) = 1.55$, $p = .282$, $\eta_p^2 = .32$, nor interactions between the two factors, $F < 1$. There were effects for prior knowledge, $F(1,141) = 25.87$, $p < .001$, $\eta_p^2 = .16$, history-related interest, $F(1,141) = 12.64$, $p = .001$, $\eta_p^2 = .08$, and media experience, $F(1,141) = 6.58$, $p = .011$, $\eta_p^2 = .05$. Overall, the participants' scores in the

Table 6
Means (with standard deviations in parentheses) for the measures of knowledge acquisition and the subjective appraisal of the learning process with the medium.

Medium	Grade level	N	Multiple choice knowledge test	Number of facts	Distribution of facts	Appraisal: expertise in the knowledge domain	Appraisal: expertise in using the medium
Common video	11	34	54.26 (5.64)	18.12 (8.82)	2.66 (0.95)	2.22 (0.51)	3.14 (0.87)
	13	22	54.05 (5.79)	20.32 (7.01)	2.76 (0.72)	3.03 (1.33)	3.18 (0.84)
	Total	56	54.18 (5.65)	18.98 (8.16)	2.70 (0.86)	2.54 (0.99)	3.15 (0.85)
Enhanced video	11	26	48.46 (4.99)	15.15 (9.71)	1.86 (1.07)	2.46 (0.83)	2.71 (0.95)
	13	12	52.50 (7.01)	16.17 (6.87)	2.44 (0.74)	2.53 (0.38)	3.47 (0.80)
	Total	38	49.74 (5.92)	15.47 (8.83)	2.04 (1.01)	2.48 (0.71)	2.95 (0.96)
Illustrated textbook	11	37	50.19 (6.39)	13.73 (7.10)	1.77 (0.88)	2.88 (0.73)	3.00 (0.58)
	13	25	51.04 (6.93)	18.48 (6.06)	2.35 (1.03)	2.51 (0.82)	3.03 (1.10)
	Total	62	50.53 (6.57)	15.65 (7.05)	2.01 (0.98)	2.18 (1.04)	3.02 (0.87)
Total	11	97	51.15 (6.20)	15.65 (8.59)	2.11 (1.03)	2.54 (0.74)	2.96 (0.84)
	13	59	52.46 (6.57)	18.69 (6.65)	2.52 (0.88)	2.71 (1.00)	3.18 (0.95)
	Total	156	51.65 (6.35)	16.80 (8.03)	2.26 (0.99)	2.60 (0.85)	3.05 (0.89)

multiple choice knowledge test ($M = 51.65$, $SD = 6.35$) could be considered average.

The essays were coded for number of facts and for distribution of facts across the medium. For number of facts, a 2 × 3-factorial nested ANCOVA with class as a nested factor and reading strategies as a covariate revealed no significant class differences, $F < 1$. Therefore, the factor class was excluded from further analysis as a nuisance factor. A subsequent 2 × 3-factorial ANCOVA with reading strategies as a covariate revealed a significant main effect of medium, $F(2,149) = 3.10$, $p = .048$, $\eta_p^2 = .04$. The students using the common video ($M = 18.98$, $SD = 8.16$) named marginally more facts than the students using the enhanced video ($M = 15.47$, $SD = 8.83$), $p = .076$. Common video and illustrated textbook ($M = 15.65$, $SD = 7.05$), $p = .166$, as well as enhanced video and illustrated textbook did not differ, $p = 1$. The main effect of grade level, $F(1,149) = 2.05$, $p = .154$, $\eta_p^2 = .01$, and an interaction of medium and grade level, $F < 1$, were not statistically significant. There was an effect of reading strategies, $F(1,149) = 7.06$, $p = .009$, $\eta_p^2 = .05$.

For distribution of facts across the medium, a 2 × 3-factorial nested ANCOVA with class as a nested factor and reading strategies and prior knowledge as covariates revealed no significant class differences, $F(6,142) = 1.22$, $p = .298$, $\eta_p^2 = .05$. Therefore, the factor class was excluded from further analysis. A subsequent 2 × 3-factorial ANCOVA with reading strategies and prior knowledge as covariates yielded a significant main effect of medium, $F(2,148) = 6.65$, $p = .002$, $\eta_p^2 = .08$. The participants using the common video ($M = 2.70$, $SD = 0.86$) named facts from more different chapters than the participants using the enhanced video ($M = 2.04$, $SD = 1.01$), $p = .011$, and the participants using the illustrated textbook ($M = 2.01$, $SD = 0.98$), $p = .005$. Enhanced video and illustrated textbook did not differ, $p = 1$. The main effect of grade level, $F(1,148) = 2.41$, $p = .123$, $\eta_p^2 = .02$, and an interaction of medium and grade level, $F < 1$, were not statistically significant. There was an effect for reading strategies, $F(1,148) = 10.10$, $p = .002$, $\eta_p^2 = .06$, and a marginally significant effect for prior knowledge, $F(1,148) = 2.83$, $p = .094$, $\eta_p^2 = .02$.

7.2.3. Subjective appraisal of the learning process with the medium

A 2 × 3-factorial nested ANOVA with class as a nested factor was calculated for the participants' subjective appraisal of the medium with regard to expertise acquisition in the knowledge domain. The analysis revealed a main effect for class, $F(6,144) = 2.68$, $p = .017$, $\eta_p^2 = .10$. The main effects for medium and grade level, both $F < 1$, as well as the interaction of the two factors, $F(2,6.45) = 3.35$, $p = .101$, $\eta_p^2 = .51$, did not reach statistical significance. Participants' overall appraisal of the media with regard to expertise acquisition in the knowledge domain can be considered average ($M = 2.60$, $SD = 0.85$).

With regard to expertise acquisition in using the medium, a 2 × 3-factorial nested ANCOVA with class as a nested factor and delay as a covariate revealed no significant main effect for class, $F < 1$. Therefore, class could be considered a nuisance factor and be excluded from further analysis. A subsequent 2-×-3-factorial ANCOVA with delay as a covariate revealed no main effect for medium, $F < 1$, but a marginal main effect of grade level, $F(1,133) = 3.72$, $p = .056$, $\eta_p^2 = .03$, with the 11th graders ($M = 2.96$, $SD = 0.84$) considering the media less useful than 13th graders ($M = 3.18$, $SD = 0.95$) regarding expertise acquisition in using the medium. There was no interaction of medium and grade level, $F(2,133) = 2.13$, $p = .122$, $\eta_p^2 = .03$. The analysis revealed an effect for delay, $F(1,133) = 4,71$, $p = .032$, $\eta_p^2 = .03$. The students' overall appraisal of the media with regard to expertise acquisition in using the media can be considered average ($M = 3.05$, $SD = 0.89$).

7.3. Discussion

In Study 2, depending on the medium at hand, students wrote essays that differed both in the number of facts they included and also in the distribution of facts across the learning material. Descriptively, students who worked with the common video received the highest scores for both measures. More specifically, the distribution of facts used for the essays revealed a significant advantage for the common video over both the illustrated textbook and the enhanced video, whereas

the latter two did not differ significantly. Also, regarding the number of facts mentioned in the essays, the common video was marginally better than the enhanced video, but did not differ from the illustrated textbook. The enhanced video and the illustrated textbook did not differ in this aspect either. Thus, in line with our expectations, the differences between the different media used were more pronounced under the realistic conditions of a homework assignment in Study 2 than under the laboratory conditions in Study 1, showing a clearer pattern of superiority of the common video over the media that offered a table of contents and an index. The general tendency for the superiority of the common video over the enhanced video was consistent over both studies. However, there was no media difference for the multiple choice knowledge test.

8. General discussion

In this section, we will offer interpretations, implications, and limitations of the two reported studies.

8.1. Interpreting the results of the two studies

Two complementary studies conducted under internally valid conditions in the laboratory (Study 1) as well as under ecologically valid conditions in the field (Study 2) showed that videos were comparable or even superior to traditional textbooks. These results are explained by the interactivity afforded by both video conditions. So how is it that the interactive videos were comparable or even superior to print? As a starting point, recall that the single steps postulated by Guthrie (1988) were: (1) formulating a reading goal, (2) identifying relevant sections of the text and sequencing their inspection, (3) extracting details from the text, (4) integrating the details with prior knowledge, and (5) recycling the postulated steps until the reading goal is met. Providing support for these steps, the features of the enhanced video were well suited to help identify relevant sections of the text/video and to sequence the inspection of the identified parts via the table of contents and the index. Both videos additionally offered features supporting the extraction of details from the text/video, for example, by stopping the video in order to write down important information.

In accordance with our first hypothesis (Hypothesis 1), Study 1 has shown that features of interactivity such as start/stop, slider and forward/rewind enabling micro-level activities are used spontaneously when participants are trying to acquire declarative knowledge. This is in line with the observations of Schwan and Riempp (2004) for procedural knowledge. When participants learned to tie nautical knots, they also spontaneously used features such as start/stop and forward/rewind to regulate the pace of presentation. These findings reflect the need of the learners to match the pace of information presentation to their own cognitive needs (Chandler, 2004; Mayer & Chandler, 2001) and to avoid loss of important information (Sturm, 1984). The extensive use of such features can possibly be explained by the familiarity of these features derived from everyday video usage, as they are common in VCRs, DVDs, and online video streaming services. Further, studies by Coté et al. (1998) and Hyönä et al. (2002) have shown that adolescent readers typically possess the relevant micro-level strategies for using these features in an appropriate manner. Additionally, the features enabling macro-level activities in the present studies were used in the enhanced video, but to a lesser extent than the features enabling micro-level activities. Spontaneous use of these features is in line with Rouet and Coutelet (2008) and as Yussen et al. (1993) who identified use of the table of contents and the index when students were locating information in textbooks.

The second hypothesis (Hypothesis 2) was concerned with the relation between the common video and the enhanced video. Both studies failed to confirm our expectation that the enhanced video should outperform the common video, because it additionally offered features allowing for macro-level activities. In contrast, there was a general tendency for the common video to be superior to the enhanced video across both studies. This superiority was reflected in the common video outperforming the enhanced video with regard to the distribution of facts across the medium (both studies) as well as the number of facts mentioned in the essays (Study 2).

Our third hypothesis (Hypothesis 3) was concerned with the relationship of the illustrated textbook and the two video conditions. We hypothesized that the illustrated textbook should outperform the common video and be comparable to the enhanced video. This hypothesis was not supported by the data. Whereas the illustrated textbook was comparable to the enhanced video, it was outperformed by the common video on one measure, namely, the distribution of facts across the medium in Study 2. Thus, there was at least a slight tendency for the illustrated textbook to be inferior to the common video, again pointing to the negative effects of the features supporting macro-level interactivity. Thus, different levels of interactivity indeed seem to be predominant over other characteristics of the media.

Considering the spontaneous use of both features for micro-level and features for macro-level activities, our findings concerning Hypothesis 2 and Hypothesis 3 argue against the model postulated by Guthrie (1988). However, one should take a closer look at the underlying strategies and implications of the implemented features before criticizing this model. Whereas the use of features for micro-level activities supporting information extraction turned out to be unproblematic (also see Schwan & Riempp, 2004), the features for macro-level activities supporting locating information caused problems. These problems might be explained by a lack of strategies underlying the use of the table of contents and the index when collecting information for an essay. In line with empirical findings by Yussen et al. (1993) and Rouet and Coutelet (2008), we do not claim that the participants lacked the skills to use these features in order to locate isolated facts. However, the use or even the mere presence of a table of contents and an index might have led to misconceptions about the distribution of information across the medium. These misconceptions reflect the assumption that all the information relevant for an essay is exclusively gathered in chapters that

are closely related to the question, ignoring other chapters of the medium as potential sources of information. Whereas this assumption is functional for questions that only refer to information located in single chapters, it is dysfunctional if the question refers to information that is distributed over large portions of a medium and the use of a table of contents and an index serves the superordinate goal of gathering this information. The latter was the case in the current studies. Thus, the participants most probably relied too much on the division of the medium into chapters that was visible in the table of contents (illustrated textbook and enhanced video) and in the slider's timeline (enhanced video only), consequentially ignoring information from other chapters that could be accessed via the index, for example. Thus, the division of the medium into chapters might have led to a rather low threshold for giving up the search for information when collecting information. Such a low threshold could be manifest in abandoning subsequent search processes such as checking the index for related information after relevant information was located in those chapters that were subjectively rated to be most relevant for the task. This explanation is in line with the observation that the differences among the media were even more clearly pronounced under realistic conditions in the field study, because the aversive situation of a homework assignment (see Warton, 2001) might even increase the tendency to stop searching for information after some first details were extracted from the medium. Based on the observation that the presence of interactive features influenced the learning outcomes even though they were hardly used (Hasler et al., 2007; Wouters et al., 2010), we would argue that the division of the medium into chapters may negatively influence the learning outcomes without necessarily being reflected in corresponding process data.

Nevertheless, it should be pointed out that despite this presumed deficiency, the enhanced video was as effective as the illustrated textbook which probably faced comparable problems although to a lesser extent (as reflected by a less pronounced difference between the common video and the illustrated textbook). One tentative explanation for this observation could be a greater salience of the division of the medium into chapters in the enhanced video than in the illustrated textbook. In the enhanced video, the chapters were visible in the slider's timeline and thus most probably noticed by the students when they used the slider for browsing. In contrast, the division of the medium into chapters was not that visible when participants browsed through the illustrated textbook.

Because the explanation of the superiority of the common video over the enhanced video (and over the illustrated textbook for one measure in Study 2) remains speculative for the moment, future research must corroborate this argumentation with empirical evidence. First, in order to show that participants have the skills to use the table of contents and the index adequately, tasks that require locating isolated information rather than information that is distributed all over the medium should be used. If participants have the skills to use the table of contents and the index, the enhanced video should clearly outperform the common video on tasks that match the granularity of these features. Second, the students' misconceptions about the distribution of facts across the medium could be corrected by offering a lesson that would train the students to be aware of the fact that not all the information is located in single chapters of the medium. With such training, the participants using the enhanced video should perform more efficiently than the participants using the common video, as the enhanced video allows for far more comfortable information gathering. Therefore, future research will have to address the usefulness of specific features for accomplishing specific tasks as well as considering learners' potential misconceptions to further optimize video use in a learning context.

8.2. Implications of the studies

The reported studies have shown that interactive videos are just as effective as print when it comes to learning. Based on this finding, an economically driven decision about which media to use in an educational setting most probably would be made by strictly focusing on production and implementation costs of the media, and eventually the conclusion would be that print is the way to go. However, there are several other factors that should be considered before taking the results of these studies as an argument against the use of videos for economical reasons.

First, Pintrich (2003) proposed to vary learning tasks and learning activities to increase the students' interest and intrinsic motivation. We believe that videos could very well serve as a promising measure to diversify the students' learning experience in the classroom. Therefore, videos might have a positive effect on the students' overall achievement by adding to a more stimulating classroom environment that entails the use of various media, tasks, and learning activities.

Second, videos offer students the opportunity to gain insight into events that they usually cannot experience in real life. In the domain of history, for example, videos might serve the purpose of giving the students an insight into past eras using documentaries or even feature movies that transport the major societal and political views that were prevalent in those eras (Stoddard & Marcus, 2010). In the domain of biology, teachers can use documentaries to show their students, for example, the hunting behavior of lions or other dangerous predators at relatively low costs and risks compared to the exposure with such animals in real life. Smith and Reiser (2005) developed a video environment allowing the decomposition of the lions' hunting behavior into single steps, fostering students' analytical skills.

The reported studies indicate that these benefits of videos do not necessarily come at the cost of learning outcomes. Even though several studies have been conducted comparing the effectiveness of traditional videos and print when participants acquire declarative knowledge (e.g., Furnham et al., 2002; Furnham & Gunter, 1985, 1987; Gunter et al., 1984, 1986; Walma van der Molen & van der Voort, 2000), the present studies are the first to address explicitly the effectiveness of

state of the art digital videos which offer interactive features to establish active and self-regulated processing of the contents. Therefore, the present studies mark a promising starting point for rethinking the effectiveness of videos, especially in the light of the digitization of the medium. With the considerable distribution of videos in leisure time (Feierabend & Rathgeb, 2008, 2009) and education (Feierabend & Klingler, 2003), the finding that videos can be just as effective as print when used as a learning tool can definitely be considered good news. The present studies have shown that videos can be just as effective as print when they afford self-regulated information processing. Therefore, the repeated observation that print is superior to non-interactive videos presented in a broadcast mode (e.g., Furnham et al., 1987; Furnham & Gunter, 1985) did not transfer to state of the art videos as used in the studies reported here. The availability of interactive features has leveled out learning related differences between print and videos. More precisely, in none of the three measures of knowledge acquisition – multiple choice test, number of facts in the essays, and distribution of the mentioned facts across the medium – did the participants of the video conditions score worse than those of the illustrated textbook condition.

Thus, the effective use of videos – just as the effective use of print – requires active and self-regulated information processing by the students. In this respect, examining the status quo of the usage of videos in classrooms, Hobbs (2006) identified several prevalent uses of video that are far from optimal. In a phone survey, teachers stated that they mainly use videos to keep the students quiet or as a reward for hard work in previous lessons – just to name a few. It is evident that videos cannot be effective learning tools under such circumstances. Therefore, methods for effective use of videos to provide active and self-regulated learning in the classroom should be implemented into teacher-training to guarantee an optimal use of videos in the years to come. Using videos as a source for writing essays in the context of a homework assignment seems to be a promising approach.

8.3. Limitations of the studies

To make an even stronger case in favor of interactive videos, non-interactive control conditions must be implemented into future studies whenever possible. We opted against the use of a non-interactive control condition in the current studies to avoid problems in the field study. Especially in a homework context, external disturbances are impossible to control for so that a non-interactive information presentation would lead to significant disadvantages of such a condition. As we worked with a topic that was directly relevant for the school curriculum, such a procedure would have been close to unethical in our real-world setting. Additionally, it would have been tricky to explain conclusively to the students why they received a computer-based video without stop functionality, because stopping could be considered a basic feature of computer-based video presentation. Especially in a homework context, this could have led to a major decrease in the students' willingness to participate in the study. To maximize the comparability of both studies, a non-interactive control condition was not implemented in the laboratory study either.

Another limitation of the studies might arise from the fact that the participants in the video conditions were given a maximum of 8 min to familiarize themselves with the videos' features. The participants in the illustrated textbook condition were not given this opportunity so that they did not take part in the same experimental steps as the participants in the two video conditions. We chose this procedure because we suspected that participants using the illustrated textbook were well aware of the positioning of features such as table of contents and an index in textbooks, as there are agreed-upon conventions that a table of contents can be found at the beginning of a book and an index can be found at the end of the book. Because there are no such conventions where to place these features in a video environment and because videos frequently do not come with a table of contents and an index, we wanted to give the students the opportunity to explore the videos' features. Of course, the contents of this familiarization phase were not relevant for the participants' main task. Another reason for the lack of such a familiarization phase in the textbook condition was that it would have been impossible to force the participants in the field study to look at a corresponding training book, whereas the training video could be mandatorily implemented into the computer-based experimental procedure for the video conditions.

Another limitation might arise from the division of the timeline in the enhanced video into ten different sections corresponding to the chapters of the video. This segmentation could have been used deliberately to access information in a specific chapter by browsing without having to use chapter selection. Thus, our numbers for the use of chapter selection might underestimate the actual use of this feature. Also, the segmentation of the enhanced video's timeline results in a greater salience of the division of the medium into chapters in the enhanced video than in the illustrated textbook, thus increasing the negative effects of any misconceptions that might arise from such segmentation. However, this segmentation did not influence the flow of information. When the students did not explicitly decide to use chapter selection or the index, information in the enhanced video was presented in the same fashion as information in the common video. Nevertheless, future studies should refrain from using segmentation in the timeline in order to allow for a clearer interpretation of the differences between experimental conditions.

With these closing remarks, it becomes evident that there still remains a lot of work to do. We hope to have encouraged other researchers to join in on this research endeavor.

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