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Comprehension across mediums: the case of text and video

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Abstract
Despite the prevalence of educational videos in today's schools and classrooms, limited work has examined the strategies students use when comprehending videos. The aim of this study is to compare pre-service teachers' strategy use when they are presented with information via text vis-à-vis via video. The study used a 2×2 experimental design with students assigned either to read or view each of two information sources. The study found strategy use to differ across mediums of information presentation, as determined through both self-report and log data. Additionally, comprehension was found to differ according to medium of information presentation, with text conferring an advantage. At the same time, students were found to have limited integration of multiple sources of information, across mediums of information presentation. Conclusions and implications for instruction and future work are discussed.

Keywords Video · Multimedia · Multiple texts · Comprehension · Integration

Introduction

Over the last 10 years, YouTube and other video-streaming platforms have become a leading destination not only for entertainment but for education as well. In a recent survey from the Pew Research Center (Purcell 2013), 64% of Internet users reported watching educational videos, 57% reported viewing news videos, and 35% reported watching political videos to gain information. Appropriately, definitions of literacy in the digital age have been expanded to include the ability to understand, use, and

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evaluate information presented not only through text, but through other mediums as well (e.g., video; Eshet-Alkalai 2004). Nevertheless, research examining how students comprehend information presented through text vis-à-vis through video has been limited. As such, the goals of this exploratory study are three-fold. First, we compare students' strategy use when presented with information across two mediums (i.e., via text vis-à-vis via video). Second, we compare comprehension across mediums of information presentation. Finally, we examine the role of medium and strategy use in students' comprehension performance.

Models of comprehension

Theories of comprehension offer insights into how students come to understand both text and video. Kintsch and colleagues have proposed the *Construction Integration Framework* (CI) to model students' comprehension (Kintsch 1988, 1998; Kintsch and van Dijk 1978). The CI framework suggests that comprehension occurs through students' formation of three cognitive models to represent the information in a source – the *proposition, text-base,* and *situation* models. In the context of text processing, the proposition model is a localized mapping of words, phrases, and the relations among them. However, two higher-level models are needed for comprehension (i.e., text-base and situation models). In the text-base model, students represent the micro- and macro-structure of text, with inferencing focused on developing within-text connections. The situation model is an integrated representation of information from the text-base with students' prior knowledge, with a coherent, general understanding of text content the result. Although the CI framework has primarily been used to understand text comprehension (McNamara and Magliano 2009), this framework can be extended to conceptualize how students derive meaning from information presented through other mediums as well. Applied to video comprehension, the CI framework suggests that students come to understand video by encoding narration and images (i.e., proposition model), mapping the sequence of information presented (i.e., text-base model), and integrating information with prior knowledge (i.e., situation model).

Specific models of multimedia comprehension, including video, have also been proposed. In particular, Mayer (2001) introduced the *Cognitive Theory of Multimedia Learning*. At its core, this model forwards three assumptions supporting the conclusion that students learn best when information is presented through multiple mediums (e.g., auditory and visual), rather than through language (i.e., auditory) alone (i.e., *multimedia principle*, Mayer 2005, p. 31). The first of these is the *dual-channel assumption*, which states that students have two working memory streams to separately process auditory and visual information. As a result, presenting students with information via narration and images offers learning advantages by making use of both of these channels for richer encoding and by affording students multiple, varied cues for retrieval. Second, the *limited capacity hypothesis* suggests that students have limited cognitive resources available to process information. As each channel for information processing is individually limited, processing the same information presented through two mediums (i.e., auditory and visual) offers students a more

elaborated learning experience, than does processing information through language alone. Finally, the *active processing assumption* poses that students are active in engaging with information. This engagement involves three distinct processes: determining relevance, organizing information, and integrating information presented across modalities (i.e., auditory and visual, in the case of video).

Since its inception, the Cognitive Theory of Multimedia Learning has been widely investigated (e.g., Höffler and Leutner 2007; Mayer and Anderson 1992; Mayer and Moreno 1998; Moreno and Mayer 1999, 2000; Plass et al. 2010). For instance, in reviewing his body of work on multimedia learning, Mayer (2005) concludes that instructional mechanisms that are effective for fostering deep-level learning in print contexts (i.e., the presentation of text with illustrations), also promote learning in digital environments (i.e., narration and animation). Nevertheless, the extent to which students' comprehension of texts compares to video comprehension, including narration and animation, requires further examination. As explained by Magliano et al. (2013), "a number of scholars who study discourse comprehension have argued that models of discourse comprehension can be viewed as general models that extend to other media. However, there are very few empirical investigations of that claim, in particular, when controlling for content" (p. 86).

In this study, in addition to examining students' processing of texts vis-à-vis videos, presenting the same content, we focus specifically on the extent to which the active processes that Mayer (1996) identifies (i.e., selection, organization, and integration) support the comprehension of information presented via video vis-à-vis via text. Magliano, et al. (2013) compared students' processing of narrative information presented via graphic texts or video. They considered students' processing of different media to differ in the front-end versus back-end processes engaged. While front-end processes were those involved in "extracting information from the visual stream," (p. 83) including the processing of both auditory and visual information, back-end processes were those involved in comprehension, or the integration of new information with prior knowledge. Magliano et al. (2013) suggested that while front-end processes differed across media, in part due to the greater linguistic demands presented by texts, back-end, or meaning-making process are more universal in nature. In this study we examine this further by comparing strategy use when students comprehend information presented via texts vis-à-vis via videos.

A preponderance of strategies supporting comprehension have been identified in the literature on text processing; however, less is known about strategies supporting video comprehension, justifying the exploratory nature of this study.

Strategies for text and video comprehension

There is a robust research base on strategies for reading comprehension. Strategies examined include summarizing, concept mapping, self-explaining, or asking elaborative questions, and attending to text structure (Afflerbach and Cho 2009; Chang et al. 2002; Duke and Pearson 2009; McNamara 2004; Meyer et al. 1980). More limited work has considered the strategies that students may engage to support video comprehension (Kim et al. 2014b; Lee and List 2018; List 2018).

Among studies examining strategies for video comprehension, the majority have focused on students' navigation behaviors during video viewing (e.g., Mu 2010; Meyer et al. 2013). Kim et al. (2014a) cataloged viewer behaviors as including: (a) *rewatching*, (b) *textual search*, (c) *visual search*, (d) *return*, and (e) *skimming*. Collectively, these behavioral strategies focus on locating and reviewing content in video, out of sequence. The *return* strategy involved backing up to a just-viewed segment of video, while *textual* and *visual search* strategies were used to navigate to previously viewed segments of video, identified by reference to a specific image or piece of narration. Perhaps reflecting the linear structure of video, *skimming* was the only strategy that involved moving forward, rather than backward, in video and represented an attempt to reduce the amount of content to be watched. Elsewhere, similar associations have been drawn between students' engagement of navigation-related behaviors and strategic video viewing (Caspi et al. 2005; Monserrat et al. 2013; Mu 2010).

Beyond navigation, a limited number of studies have examined the cognitive strategies students deploy during video comprehension (Lee and List 2018; List 2018). Within the context of second language learning, Lin (2009) developed a questionnaire to capture students' comprehension strategies while watching video segments. Three categories of strategies were identified: *memory strategies*, *cognitive strategies*, and *compensatory strategies*. *Memory strategies*, like reviewing, reflected students' attempts to encode new information or to retrieve previously learned information. As a contrast, *cognitive strategies* was the term applied to students' efforts to achieve higher-level understanding by summarizing or analyzing content in video. *Compensatory strategies* (e.g., guessing, inferencing), as identified by Lin (2009), reflected students' attempts to fill in meaning, despite deficits in linguistic knowledge. This final set of strategies may be less applicable to video viewing in other domains.

Perhaps most relevant to the present study is work examining pre-service teachers' video viewing. Colestock and Sherin (2009) identified five video viewing strategies supporting comprehension, including: (a) *comparison*, (b) *generalization*, (c) *perspective-taking*, (d) *reflecting thinking*, and (e) *problem solving*. *Comparison* involved viewers relating video content to previously encountered information, either in earlier accessed sources or in prior knowledge. *Generalization* reflected pre-service teachers identifying concepts at multiple points throughout a video segment. *Perspective-taking* involved students adopting the point-of-view of actors or agents in the video clip. *Reflective thinking* captured individuals' personal responses to video content. Finally, *problem solving* referred to viewers' understanding of video content as an organized series of steps, characterized by a goal and actions toward the goal. Pre-service teachers most commonly used comprehension strategies, relying on problem solving (32%), perspective taking (24%), and making comparisons (19%) when viewing videos of classroom interactions. While the strategies that Colestock and Sherin (2009) identified were effective in capturing how pre-service teachers understood and responded to videos of dynamic classroom scenarios, more needs to be understood about how pre-service teachers may make sense of videos from other genres. For instance, the utility of perspective-taking or problem solving comprehension strategies may be confined to instructional video

viewing. In this study, we seek to identify the navigation and comprehension strategies undergraduate pre-service teachers engage when viewing informational videos for the purpose of lesson planning. We expected the strategies reported in this study to reflect both the behavioral or navigation strategies described by Kim et al. (2014a) and the more cognitive strategies identified in Colestock and Sherin's work (2009).

Present study

In this study, we examine students' strategy use and comprehension when information was presented via text vis-à-vis via video. Strategy use was captured through both behavioral and log data and through students' self-report. We had the following research questions:

1. What strategies do participants use when presented with information via text vis-à-vis via video?
2. What is the relation between medium of information presentation and comprehension?
3. To what extent do medium of information presentation and strategy use predict participants' comprehension performance?

Due to the dearth of prior research on video comprehension, specific hypothesis could not be formed. Indeed, this study may be considered to be exploratory in nature. Nevertheless, we generally expected information presentation via text to confer comprehension advantages over video-based information presentation, given students' greater familiarity with text as a medium.

Methods

Sample and research design

Participants were 91 undergraduate students at a large Midwestern university in the United States (age: $M = 20.30$, $SD = 2.76$). The sample was majority female (80.22%, n = 73; male: 19.78%, n = 18) and majority White (92.31%, n = 84). Further, 4.40% of students identified as Latino (n = 4), 2.20% of students were African American (n = 2), and 1 student was Asian (1.10%). Participants were perusing a variety of majors related to education and were representative of education majors at the university. Table 1 summarizes participant demographics.

Pre-service teachers were selected as the population of interest for two primary reasons. On the one hand, they were considered to be representative of other undergraduate students, commonly using educational videos for learning (Israel 2015). On the other hand, they were expected to soon be responsible for selecting videos to use for instruction in their classrooms. Indeed, to the extent that teachers have commonly been found to use videos in class to promote student learning (Berk 2009; Mullen and Wedwick 2008), we considered examining pre-service teachers' own

Table 1 Participant descriptives

	Mean	SD
Age	20.30	2.76
	N	%
Race/ethnicity		
White	84	92.31%
Hispanic/Latino	4	4.40%
African American	2	2.20%
Asian	1	1.10%
Class standing		
Freshman	21	23.08%
Sophomore	37	40.66%
Junior	20	21.98%
Senior	12	13.19%

strategies for video comprehension and associated performance to be critical areas of examination.

A 2×2 experimental design was used, with participants randomly assigned to read or view each of two sources as either a text or a video, with four conditions resulting (i.e., read two texts; view two videos; read a text and view a video; view a video and read a text). The last two mixed medium conditions, wherein students read a text and viewed a video, were collapsed in analyses.

Procedures

The study had four main parts. First, participants completed a variety of individual difference measures. These included a demographics questionnaire and a prior knowledge assessment. Then, participants completed a two part task, involving research and response composition. Specifically, participants were given two information sources on the topic of keystone species, presented digitally as either texts or videos (i.e., research phase) and told to use the sources in order to create an instructional script to teach students about the topic of keystone species. Second, participants were asked to compose an instructional script for upper elementary school students (i.e., response composition phase). Participants were further told that they could take notes on the two information sources, during the research phase of the study and that while they would not be able to use the two information sources during response composition, their notes would be available to aid in task completion. Finally, participants completed post-task measures, including a self-report strategy inventory (Bråten and Strømsø 2011) and a post-task knowledge measure, to assess comprehension.

Participants completed all study materials online, via the Qualtrics platform on computers in a laboratory, reserved for the purpose of data collection. Participants completed the study in groups of less than 10, with the researcher present.

Measures

Knowledge

Prior knowledge was assessed by asking participants to complete a ten-item, open-ended, term-identification measure. Specifically, participants were instructed to *please tell us what you know about each of the following terms*. Terms were drawn from key concepts discussed in the two information sources including, *keystone species, keystone mutualists, keystone modifiers, trophic cascade*, and *apex predator*.

Students' definitions were scored on a binary scale as correct (1) or incorrect (0), with scores ranging from 0 to 10. At pre-test, the 10-item measure had a Cronbach's alpha reliability of 0.68. The mean score, out of a possible ten correctly identified terms, was 2.78 ($SD = 1.78$), indicating that students constituted a low knowledge sample. Participants did not vary in prior knowledge scores across conditions of information presentation ($p = 0.44$).

Information sources

First, participants were given two information sources on the topic of keystone species (i.e., species that play a disproportionately important role in their ecosystems relative to population size; Mills et al. 1993). Participants were randomly assigned to have each information source presented as either a text or a video. As a result, participants could be presented with the two information sources as either: (a) two texts, (b) two videos, or as a (c) text and a video. Prior to being presented with each source, as a text or a video, participants were instructed that they would be asked to use the information in the two sources to create an instructional script to teach students about the topic of keystone species.

Information presentation

The two information sources were complementary, presenting information on the same topic that was distinct (i.e., largely unique to each source) but not discrepant. The first source explained the five different types of keystone species, while the second source elaborated on the effects of one specific keystone species, the gray wolf, on the ecosystem of Yellowstone National Park. While the first source was expository in nature, presenting information in a highly organized fashion, the second source adopted a more narrative tone, explaining changes to Yellowstone after wolves were first removed from and then reintroduced into the ecosystem. Because the sources were complementary, following an explanation-example structure, all participants received the two information sources in the same order. Participants were not expected to have a great deal of prior knowledge on the topic of keystone species and presenting the explanatory or more expository source first was considered to be an effective mechanism for introducing students to the topic.

Sources were identified by first selecting videos meeting a number of criteria and, then, transcribing each video to create a text-based version of each information source. Videos were selected based on topic, length, production quality, narration,

and the absence of human actors. The first information source, *Keystone Species and their Role in Ecosystems* was a 4.00 min video that, when transcribed, was a 492 word text. The second information source, *Wolves of Yellowstone*, was a 5.33 min video, corresponding to a 614 word text, when transcribed.

Response composition

Because participants were perusing majors related to education, an education-related task was created to motivate source use. Specifically, students were asked to write an instructional script about keystone species for upper elementary school students, using information in the two sources. Specifically, participants were instructed to: *include all of the information that you would like to share with students, as you would present it to the class*, in their instructional scripts. Participants were told that there was no time limit for the task.

Comprehension performance

After participants had finished completing their instructional scripts, they were again asked to complete the ten-item term identification measure that was used to assess prior knowledge. At post-task, the full ten item measure had a Cronbach's alpha reliability of 0.73.

Instructional scripts

Participants' instructional scripts were coded in two ways. First, the number of information-based statements, originating from either information source, included in students' instructional scripts was totaled. Across two raters, the number of information-based statements identified in participants' responses had a Cronbach's alpha reliability of 0.92, based on 19 responses scored (20.88%). We were further interested in the extent to which participants included integrative statements, or statements explicitly linking the two information sources, in their responses. Although the number of integrative statements in students' instructional scripts was coded for, limited integration was identified. Participants' responses closely mirrored the information, as it was presented in the two sources, with limited integration or information transformation exhibited. As such, whether or not students integrated the two sources was coded as a binary variable.

Strategy

Two types of strategy measures were collected. These were behavioral or log data, gathered during students' information use, and students' self-reports of strategy use, after task completion. These two approaches to the collection of strategy data were adopted for a number of reasons. First, these presented an unobtrusive method of data collection, one that was not expected to interrupt the regular course of processing in the same way that a more intrusive method of data collection (e.g., think-aloud) would. Second, using a strategy inventory, in particular, allowed us to ask

students about the use of those strategies (e.g., strategies associated with cross-textual elaboration) that were of greatest interest to us in this study, while minimizing researcher interpretation regarding what types of strategies students were reporting, a limitation common to more open-ended methods of strategy assessment. At the same time, students' reports on the strategy inventory were able to be supplemented with log or behavioral data of their strategic engagement during video viewing.

Self-report data

Following response composition, participants were asked to complete an 18-item strategy inventory. This strategy measure was drawn from two scales developed by Bråten and Strømsø (2011) to capture information accumulation and cross-textual elaboration when students process multiple texts. These two scales may be thought of as corresponding to surface- and deep-level strategies for information use, respectively (Dinsmore and Alexander 2012, 2016). An additional scale was created to capture students' strategies for organizing information, a set of strategies expected to be potentially pertinent to students' video comprehension, as per Mayer (2005). The information accumulation scale asked students to report the extent to which they *tried to gather as much factual information as possible* or *tried to remember as much as* possible from the two sources. This scale included a total of seven items and had a Cronbach's alpha reliability of 0.90. Conversely, the cross-textual elaboration scale asked students to endorse items such as the extent to which they *tried to compare the two sources to one another* or *tried to find ideas that recurred in the two sources*. This was a six-item scale, with a Cronbach's alpha reliability of 0.93. The information organization scale consisted of five researcher-developed items. Items included asking students to report the extent to which they *tried to organize the information in the two sources* or *tried to identify key concepts in the two sources*. The scale had a Cronbach's alpha reliability of 0.76. Across scales, items were rated on a seven-point scale, ranging from students reporting engaging strategies *not at all* to *a great deal*. Participants were asked to report their strategy use across the two information sources encountered, rather than separately for each source. The general term *source* was used in all items to apply to information presented either through text or through video.

Behavioral data

Log data were collected during participants' use of each information source. Specifically, we considered the total amount of time students devoted to viewing or reading the first and second information sources.

Video coding

Additionally, for a sub-set of participants (n = 17; 18.68%), screen-capture software was used to record students' screens during task completion. Of the 17 participants whose screens were recorded, 13 students (14.29%) viewed at least one video during

task completion. The resulting screen-capture videos were coded to more specifically identify the strategies students employed during video viewing.

Videos were coded using Behavioral Observation Research Interactive Software (BORIS; Friard and Gamba 2016). Prior research (e.g., Kim et al. 2014a; Mu 2010) was used to establish an initial pool of expected viewing behaviors, including pausing, restarting, and rewinding. The coding scheme was then updated to include behaviors not previously identified (e.g., previewing).

Participants demonstrated a total of seven different viewing behaviors. These included: (a) *adjusting volume*, (b) *pausing* the video, (c) *restarting* the video, (d) *scanning backward*, (e) *scanning forward*, and (g) *rewinding*. *Adjusting volume* included increasing or decreasing volume either within the video player or using the computer's volume setting. *Pausing* reflected participants briefly stopping the video, while *restarting* corresponded to subjects resuming playback, following a pause. *Scanning forward* or *backward* referred to participants moving their cursor over the video's progress bar to review or preview content, without navigating to those particular segments of video. *Rewinding* was when participants navigated back to a previously viewed section of video. While students had the option of navigating ahead to view upcoming video content, out of order, no participants elected to do so. Due to the exploratory nature of this study, results of students' video navigation are only presented descriptively, in response to the first research question.

Results

Research question 1: strategy use across conditions

Data on strategy use were collected by asking students to complete a strategy inventory following the task, by examining log data to determine time devoted to information use, and by coding screen-capture videos of video viewing, for a subset of participants.

When examined strategy use, only the conditions where students viewed two texts vis-a-vis two videos were compared; with the combined text and video conditions excluded. Three dimensions of strategy use (i.e., information accumulation, cross-textual elaboration, and information organization) were examined. Analysis of variance determined that participants in the two texts and two videos conditions differed significantly in their reported engagement in information accumulation, $F(1, 43) = 6.69$, $p < 0.05$, $\eta^2 = 0.13$, corresponding to a large effect. In particular, participants reading two texts ($M = 5.07$, $SD = 0.66$) reported engaging in information accumulation to a much greater extent than did participants viewing the two videos ($M = 4.47$, $SD = 0.89$). Likewise, ANOVA determined that participants in the two texts condition ($M = 4.47$, $SD = 1.10$) reported engaging in cross-textual elaboration to a significantly greater extent than did participants in the two videos condition ($M = 3.79$, $SD = 1.01$), $F(1, 43) = 4.50$, $p < 0.05$, $\eta^2 = 0.09$, indicating a medium effect. Finally, the two conditions differed significantly in their reported use of organizational strategies, $F(1, 43) = 5.01$, $p < 0.05$, $\eta^2 = 0.10$, a medium-large effect. As with other strategy dimensions, participants in the two texts condition reported

a greater degree of strategy use than did participants in the two videos condition (texts: $M = 4.86$, $SD = 0.80$; videos: $M = 4.37$, $SD = 0.64$). Table 2 summarizes students' reported strategy use and task performance across conditions.

Time on source use was compared for participants presented with each of the two information sources as either a text or a video. For the first information source, participants devoted significantly more time to reading the text ($M = 11.22$ min, $SD = 4.19$), than they did to viewing the video ($M = 8.89$, $SD = 4.17$), $F(1, 88) = 7.02$, $p = 0.01$, $\eta^2 = 0.07$, indicating a medium effect. As a note, the first video was only four minutes in length, indicating that, on average, participants engaged in substantial navigation corresponding to viewing the video at least twice. Time devoted to information access did not vary with medium of information presentation for the second information source, $p = 0.90$. Participants devoted an average of 7.94 ($SD = 3.90$) minutes to viewing the 5.33 min video, indicating a modest degree of navigation; although not to the extent exhibited when viewing the first video.

A subset of participants' screens were recorded during task completion; 13 participants viewed at least one video, resulting in a total of 19 video viewings recorded. Across both videos, a total of 258 navigation behaviors were observed. The most common behaviors manifest was to pause (33.72%, n = 87) and restart (32.17%, n = 83) the video. Other behaviors recorded included scanning backwards (19.38%, n = 50), rewinding (8.14%, n = 21), scanning forward (3.49%, n = 9), and adjusting volume (3.10%, n = 8). Participants' navigation behaviors are summarized in Table 3.

Video 1 was viewed by 11 of the 13 participants whose screens were recorded. One participant watched the video straight through, without exhibiting any navigation behaviors. The most commonly manifest behaviors were students pausing and restarting the video; both behaviors were performed by 90.09% of participants (n = 10). Participants paused Video 1 an average of 6.45 times ($SD = 5.89$) during viewing; they restarted Video 1 an average of 6.18 times ($SD = 5.65$). Other common behaviors included scanning backwards, manifest by 72.73% participants (n = 8), with an average frequency of 4.00 times per viewing, ($SD = 3.58$), and rewinding

Table 2 Descriptives of all strategy measures and performance outcomes across conditions

	Condition		
	Two texts M (SD)	Two videos M (SD)	Text and video M (SD)
Strategies			
Accumulation	5.07 (0.66)	4.47 (0.89)	4.86 (0.93)
Elaboration	4.47 (1.10)	3.79 (1.01)	3.94 (1.18)
Organization	4.86 (0.80)	4.37 (0.64)	4.60 (0.91)
Comprehension			
Post-task knowledge	7.04 (2.18)	5.81 (2.66)	6.24 (2.45)
Number of statements	16.75 (10.36)	15.48 (10.03)	21.44 (9.51)
Integration			
Switches	1.00 (0.98)	0.71 (0.64)	1.04 (1.19)

Table 3 Navigation behaviors observed in video condition

Behavior	Video 1		Video 2		Total	
	% participants	M (SD)	% participants	M (SD)	% participants	M (SD)
Adjusting volume	18.18 (n = 2)	0.64 (0.92)	12.50 (n = 1)	0.13 (0.35)	15.79 (n = 3)	0.42 (0.77)
Pausing	90.91 (n = 10)	6.45 (5.89)	25.00 (n = 2)	2.00 (2.14)	63.16 (n = 12)	4.58 (5.11)
Restarting	90.91 (n = 10)	6.18 (5.45)	25.00 (n = 2)	1.88 (1.81)	63.16 (n = 12)	4.37 (4.88)
Scanning backward	72.73 (n = 8)	4.00 (1.83)	25.00 (n = 2)	0.75 (1.49)	52.63 (n = 10)	2.63 (3.27)
Scanning forward	27.27 (n = 3)	0.82 (1.83)	0.00 (n = 0)	0 (0.00)	15.79 (n = 3)	0.47 (1.43)
Rewinding	72.73 (n = 8)	1.91 (2.34)	0.00 (n = 0)	0 (0.00)	42.11 (n = 8)	1.11 (2.00)

(72.73%, n = 8; $M = 1.91$, SD = 2.34). Scanning forward was demonstrated by 27.27% of students (n = 3; $M = 0.82$, $SD = 1.83$), while 45.45% of students adjusted volume during viewing (n = 5, $M = 0.64$, $SD = 0.92$).

Video 2 was viewed by 8 of the 13 participants, with 5 participants watching the video straight through. As a result, only 37.50% (n = 3) of students exhibited any navigating behaviors during viewing. In the second video, pausing and restarting within the video was manifest by 25.00% of students (n = 2, $M = 2.00$, $SD = 2.14$). The only other behaviors recorded were scanning backward (25.00%, n = 2, $M = 0.75$, $SD = 1.49$) and adjusting volume (12.50%, n = 1, $M = 0.13$, $SD = 0.35$).

Research question 2: comprehension

Students' performance on a post-task knowledge measure was the primary comprehension measure examined in this study. A two-way ANOVA was used to predict comprehension. Medium of information presentation (i.e., text or video) for each source was entered as an independent variable. There was a significant main effect for medium of information presentation for the first information source, $F(1, 85) = 4.58$, $p < 0.05$, $\eta^2 = 0.05$, indicating a small to medium effect, but not for the second information source, $p = 0.80$. The interaction between conditions, indicating consistency of information presentation, was likewise not a significant differentiator of post-task knowledge scores, $p = 0.77$. Participants receiving the first information source as a text scored significantly higher on the post-task knowledge measure ($M = 6.91$, $SD = 2.15$) than did participants receiving the information via video ($M = 5.80$, $SD = 2.62$).

Research question 3: medium and strategy use in comprehension

Additionally, a step-wise regression was run predicting comprehension scores based on prior knowledge (Step 1), medium of information presentation (Step 2), time devoted to engaging with each information source (Step 3), and reported strategy

use (Step 4). The final model was overall significant, $F(8, 80) = 7.25$, $p < 0.01$, $R^2_{adj} = 0.36$, indicating a large effect. Despite the regression being significant, overall, prior knowledge was the only predictor found to be individually significant in the model ($\beta = 0.47$, $p < 0.001$). This regression model is summarized in Table 4.

Instructional scripts

We further examined the extent to which prior knowledge, medium of information presentation, time on source use, and reported strategy use had an effect on the instructional scripts that students generated. Instructional scripts were coded in two ways. Specifically, these were coded both for the number of information-based statements from each information source included and for the number of integrative statements, linking the two information sources together, featured in participants' responses. On average, participants' responses included 10.44 ($SD = 6.67$) statements from the first source, 8.36 statements from the second source ($SD = 6.80$), and 0.96 ($SD = 1.23$) integrative statements. Due to the low number of integrative statements included in participants' responses, these were recoded into a binary variable reflecting any presence of integration or not. Generally, participants' response closely mirrored the information sources, as these were presented.

A two-way ANOVA was used to predict the extent to which the number of information-based statements in participants' instructional scripts was associated with medium of information presentation (i.e., text or video) either for the first or the second information sources. While neither of the main effects, capturing whether either the first source or the second source were presented as a text or as a video, were significant ($ps > 0.46$), a significant interaction effect did emerge, $F(1, 90) = 6.65$, $p < 0.05$, $\eta^2 = 0.07$, indicating a medium effect. Specifically, participants receiving

Table 4 Regression model predicting post-task knowledge scores

	Unstandardized		Standardized	
	B	SE	β	*p*
Step 1				
Prior knowledge	0.65	0.12	0.47	0.00
Step 2				
Medium source 1	−0.31	0.44	−0.06	0.48
Medium source 2	−0.05	0.44	−0.01	0.92
Step 3				
Time source 1	0.04	0.06	0.07	0.53
Time source 2	0.05	0.07	0.08	0.49
Step 4				
Info. accumulation	0.23	0.38	0.08	0.56
Cross-text elaboration	−0.11	0.26	−0.05	0.68
Info. organization	0.83	0.46	0.28	0.07

Coefficients based on final step of the regression model

$F(8, 80) = 7.25$, $p < 0.001$; $R^2_{adj} = 0.36$

the first information source as a text and the second as a video ($M = 22.43$, $SD = 9.38$) included significantly more information-based statements in their responses than did participants viewing both sources as videos ($M = 15.48$, $SD = 10.03$).

A model was run predicting the amount of information-based statements in participants' responses based on prior knowledge (Step 1), medium of information presentation (Step 2), time devoted to information access (Step 3), and self-reported strategies engaged (Step 4). The final model was overall significant, $F(8, 81) = 2.92$, $p < 0.01$, $R^2_{adj} = 0.15$. However, none of the individual predictors in the model were significant. Table 5 includes a model summary.

A binary logistic regression was run predicting whether or not participants included integrative statements in their instructional scripts based on prior knowledge (Step 1), medium of information presentation (Step 2), time on source use (Step 3) and self-reported strategy use (Step 4). However, the model was not significant overall ($p = 0.10$).

Conclusion and implications

This study examined students' reported and demonstrated strategy use and comprehension performance when presented with information as either a text or a video. Differences in medium were found to result in differences in reported strategy use. Models including medium of information presentation and students' reported strategies for information use were found to be significant in predicting comprehension outcomes.

This study contributes to the extant literature on multimedia information use in at least three ways. First, it contributes to the literature on comprehension across

Table 5 Regression model predicting number of information-based statements in students' presentation scripts

	Unstandardized		Standardized	
	B	SE	β	*p*
Step 1				
Prior knowledge	−0.63	0.58	−0.11	0.28
Step 2				
Medium source 1	0.27	2.10	0.01	0.90
Medium source 2	0.83	2.08	0.04	0.69
Step 3				
Time source 1	0.24	0.29	0.10	0.41
Time source 2	0.46	0.32	0.18	0.15
Step 4				
Info. accumulation	3.26	1.80	0.28	0.08
Cross-text elaboration	−1.89	1.25	−0.21	0.14
Info. organization	1.28	2.17	0.11	0.56

Coefficients based on final step of the regression model
$F(8, 81) = 2.92$, $p < 0.01$, $R^2_{adj} = 0.15$

mediums. Considerable work has been devoted to investigating students' text comprehension (e.g., Graesser et al. 1994; McNamara and Magliano 2009), with more limited work, particularly beyond the domain of language learning, examining students' comprehension of information presented via video (e.g., Caspi et al. 2005; Ellis and Childs 1999; Rich and Hannafin 2008; Peters and Clarebout 2014). This study takes such investigations a step further by, not only examining video comprehension, but also comparing comprehension when students are presented with information via video vis-à-vis via text. Second, this study contributes to the burgeoning literature on strategy use during video viewing (e.g., Guo et al. 2014; Kim et al. 2014a; Lee and List 2018; List 2018; Sinha et al. 2014; Taylor 2005) and examines both behavioral and self-reported measures of strategy use. Finally, given the study sample, we also contribute to investigations of pre-service teachers' technology and information use in lesson planning.

Strategy use

Limited prior work has examined differences in students' strategic processing when information is presented via text vis-à-vis via video. In this study, intriguing differences were found in strategy use across these two mediums. Specifically, participants assigned to either the text or video medium conditions differed on all three of the strategy sub-scales examined in this study, including both low-level (i.e., information accumulation) and high-level strategies (i.e., organization, cross-textual elaboration; Bråten and Strømsø 2011; Dinsmore and Alexander 2012, 2016). Across the three strategy sub-scales considered, participants presented with information via two texts reported a higher degree of strategy use than did their counterparts in the two videos condition.

Although more work is needed to validate students' reporting of strategies used, there may be at least three explanations for why strategy use was more limited in the two videos condition. First, participants may have had limited experience or training in viewing videos for academic purposes. While strategies for text processing are often emphasized in school curricula (e.g., Afflerbach et al. 2008; Mokhtari and Reichard 2002), strategies for video viewing are likely introduced to a much more limited extent. Second, the nature of video viewing, per se, may have discouraged students' strategy use because of its immersive or unstructured nature. Students find videos to be highly engaging (Duffy 2008; Mitra et al. 2010; Sherer and Shea 2011); as a result, videos may foster an illusion of understanding among students, dampening their deployment of critical or deep-level processing strategies. In a similar vein, easier to read or more coherent texts have been found to spur students' deep-level strategy use to a more limited extent than do more challenging or less coherent texts (McNamara and Kintsch 1996). As an alternate explanation, videos' linear structure and lack of organizational markers (e.g., headings, paragraphs) may have inhibited strategy use, as has been suggested in prior work (Ding and Marchioni 1998; Green et al. 2000). Structure, organization, and conformity to genre have all been found to play an important role in facilitating text processing and comprehension (Kendeou

and van den Broek 2007; Meyer et al. 1980; Taylor and Beach 1984); these features are less available in video, potentially reducing strategy engagement.

Third, the specific videos selected for this study may have violated the modality effect introduced by Mayer (2014). Specifically, Mayer suggests that presenting information auditorily and visually enhances comprehension in cases where images serve to complement, exemplify, or otherwise enrich the auditory information presented. As a contrast, when images do not serve a complementary function (Mayer et al. 2001; Schnotz and Bannert 2003) or when auditory and visual information presentation results in split-attention (Mayer and Moreno 1998; Moreno and Mayer 1999), dual-modal sources may negatively impact performance by increasing cognitive load. The videos used in this study included narration accompanied by images of the keystone species discussed. These images may have done little to support video comprehension, rather, as suggested by Mayer et al.'s analysis (2001), these may have served as seductive details, reducing the working memory resources available for students' strategy deployment.

Beyond examining students' self-reported strategy use, behavioral data provide intriguing insights into the strategies students engage during video viewing. The viewing strategies identified in this study were consistent with patterns of navigation previously catalogued (e.g., Kim et al. 2014a; Monserrat et al. 2013; Mu 2010). For instance, as in prior work, participants in this study navigated backward, to previously viewed content, much more commonly than they scanned forward to preview upcoming information (Caspi et al. 2005). By far the most frequently engaged behaviors were students pausing and restarting videos during viewing. These behaviors point to students' efforts to adjust the rate of information delivery, rather than attempts to change the order in which information was accessed.

Nevertheless, pausing and restarting behaviors were not evenly distributed across the two information sources. Rather, participants paused while watching the first video much more frequently than they did when viewing the second information source. This pattern of findings seems to indicate a strong genre effect, wherein the first, more structured or expository source, resulted in more engaged navigation during video viewing than did the second, more narrative source. Additionally, the nature of auditory and visual integration in this first video may have encouraged pausing; specifically, this first information source occasionally flashed terms on the screen to accompany narration. Indeed, when participants paused the first video it was often times while textual information was on the screen. Likewise, when students accessed video content out of sequence, by scanning backwards or rewinding, often, this backwards navigation was to specific instances of textual display. It seems that text on screen may have acted as an attentional cue, directing students toward important information, and prompted the engagement of navigation behaviors like pausing. Further, the presence of text may have served as a structural break that participants could use as a navigational guide or as a dividing line for video content. Nevertheless, these organizational features may have been insufficient given that being presented with the first information source as a text, rather than as a video, was nevertheless associated with improved comprehension at post-test.

The second, more narrative, information source was characterized by an absence of text embedded in the video. This lack of text, along with the more narrative

quality of the second video, may account for the large proportion of participants who watched this information source straight through, without demonstrating any navigation or viewing behavior. Collectively, students' manifest navigation behaviors indicate the importance of video genre and the embedding of text in videos for strategic comprehension.

Comprehension

In this study, students' performance on a post-task term identification measure was used as a measure of comprehension. This comprehension outcome was examined as differing according to medium of information presentation. Difference to emerge were that presenting the first, more expository information source as a text, rather than as a video, was associated with higher post-task knowledge scores.

Nevertheless, the effect of medium of information presentation on comprehension performance was modest. This may have been the case for a number of reasons. First, comprehension differences across mediums may manifest more acutely when the information to be processed is lengthier or more difficult for students to understand. The benefits of text-based information presentation found for students' comprehension of the first, more expository source, but not for the second, narrative source, may be indicative of this trend. Further, given the significant interaction found between mediums of information presentation, it may be the case that, particularly for low knowledge students, initially presenting content via text facilitates subsequent video viewing. Based on the analyses in this study, there is reason to believe that text, over video, may be the more facilitative medium for information presentation. Reasons for this may include that texts offer students more comprehension-supporting structural features, like headings and paragraphs, than do videos (Ding and Marchioni 1998; Green et al. 2000), or that students find videos to be seductively interesting or immersive (Mayer et al. 2001), depressing strategy use. Nevertheless, there is a need to more systematically examine the role of various source features, including length, difficulty, and genre, as these may moderate the association between medium of information presentation and comprehension.

Another reason potentially dampening differences in participants' comprehension performance across mediums was that, across conditions, students were allowed to take notes during information use. Indeed, all of the participants in this study elected to do so, to varying extents. Kobayashi (2009a, b) stresses the commonality of note-taking or external strategy engagement, especially when participants have to comprehend information based on multiple sources (Stahl et al. 1996). In this study, being able to externally represent the structure of information during note-taking may have particularly benefitted students in the video-based information presentation conditions. Students viewing videos may have been able to use their notes to compensate for the more linear and less overtly structured nature of this medium (Ding and Marchioni 1998; Green et al. 2000). Pragmatically, students' note-taking meant that, regardless of medium of information presentation, participants transferred source-based information to written notes, prior to completing the term identification measure at post-test and composing their instructional script. While

transferring information from video to primarily linguistic-based notes may have been more difficult for students than text-based note taking (Mu 2010), students' uniform use of text-based notes, across conditions, may have reduced the differences in comprehension, across mediums, identified.

Integration in instructional scripts

Instructional scripts were selected as an outcome measure because of their pertinence to students taking education-related courses and were intended to tap pre-service teachers' information use for lesson planning. Nevertheless, the instructional scripts that students generated proved to be of limited probative value. First, the information that they included largely mirrored that presented in the information sources, both in content and in structure. Moreover, although both of the information sources were focused on a common topic, keystone species, participants integrated these sources to a limited extent. Rather, participants discussed one source and then the second, rather than explicitly describing how the second source exemplified the first. Doubtless, further investigation of pre-service teachers' information use for lesson planning is necessary, particularly as this is an under-examined area of research. Nevertheless, this initial, exploratory study seems to point to deficits in this regard.

Limitations

A number of limitations associated with this study must be acknowledged. First, the information sources we used, across both text and video presentation conditions, were not counterbalanced. Rather, the expository or more informational source was intentionally presented to participants first, ahead of the more narrative source. We decided to keep order of source presentation consistent across subjects because most study participants were not familiar with the topic of keystone species. We thought that the expository information source would be more accessible for novice learners and better introduce students to the topic of the task. Nevertheless, this study should be replicated with counterbalanced information sources and further work should more systematically examine the role of genre in text and video processing.

Second, participants were asked to self-report their strategies for information use, collectively, after being presented with both information sources, rather than separately, in reference to their use of each particular information source. A more fine-grained analysis of strategy use is needed. Future work should directly assess strategies following students' engagement with different sources presented as either texts or videos (Lee and List 2018; List 2018). Moreover, strategy use should further be corroborated against behavioral and log-based metrics of source use. The strategy assessment used in this study (Bråten and Strømsø 2011) was based on an existing measure used to capture strategy engagement during multiple text use. The extent to which this measure was appropriate to use when examining strategy use during video viewing has yet to be determined. Additional work is needed to develop and validate measures of strategic processing pertinent to video viewing.

An interesting finding to emerge as a result of this study is the role of video genre in comprehension. The literature on text processing has long documented differences in students' comprehension of narrative vis-à-vis expository texts (Best et al. 2008; Eason et al. 2012). The role of genre in video comprehension has yet to be systematically examined but represents a promising avenue of research, emerging from this study. Comprehension was assessed in this study via multiple choice items and open-ended questions, which may also be considered to be measures of recall. Further measures of comprehension, that more comprehensively tap situation model construction, should be considered in further documenting the relative effects of text vis-à-vis video presentation on learning.

Despite these limitations, we consider this to be an important initial investigation in understanding students' strategic processing during video viewing. We document differences in strategy use across mediums (i.e., when information is presented via text or via video) as well as taxonomizing the kinds of navigation behaviors that students engage in during video viewing. Medium of information presentation and strategy use were associated with performance outcomes, to varying extents, suggesting methods whereby comprehension may be developed in undergraduate students and pre-service teachers alike.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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