Processing of texts and videos: A strategy-focused analysis

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Abstract
This study examined strategies used across two modalities of information presentation. Students were presented with two sources on endangered species, either as two texts or two videos. Then, participants were asked to annotate the two sources either using the track changes function in Microsoft Word, for the text condition, or using the VideoAnt, video annotation platform, for the video condition. Students' annotations were coded for the strategies evidenced. More strategies were reported in association with the text condition and a greater number of higher-level strategies and emphasis-related strategies were reported. Moreover, students were found to report consistent strategies when processing two different sources, on two different topics, and were found to report strategies disproportionately early during processing, particularly for the video condition.

1 | INTRODUCTION

According to the National Assessment of Educational Progress, only 37% of 12th grade students performed at or above proficiency in reading in 2015, indicating serious deficits in many learners' comprehension skills when reading. Fittingly, extensive work has been done to identify, teach, and intervene to develop strategies that improve students' comprehension performance on reading tasks. Strategies for reading have been conceptualized as active in nature, metacognitively engaged, goal-directed, focused on meaning making, and constructively responsive to text (Afflerbach, Pearson, & Paris, 2008; McNamara, 2004; McNamara, O'Reilly, Rowe, Boonthum, & Levinstein, 2007; Pressley & Afflerbach, 1995). Despite the breadth of strategies to improve reading identified in the research literature, two gaps persist. First, strategies have been examined in a binary fashion, as being used, or not, during reading, rather than as unfolding dynamically during the course of processing. Second, the extent to which the comprehension strategies that students use during reading also support the comprehension of information presented through other modalities, namely video, has yet to be established. In this study, we examine patterns in strategy use, emerging during the course of reading or video viewing, when students are presented with information via text vis-à-vis via video.

We considered students' processing of videos to be particularly important to examine, given the increased use of videos in today's classrooms. For instance, in 2014, Khan Academy instructional videos were viewed by 10 million unique users each month, whereas over 250,000 teachers were members of the Ted-Ed network, using the same instructional videos in their classrooms, as were used in this study. This suggests the importance of understanding how and how well students learn from information presented via video and comparing the quality of students' learning from videos vis-à-vis from texts.

2 | STRATEGIES FOR COMPREHENSION

Strategies to support reading comprehension have been categorized in a variety of ways. McNamara (2004) comprehensively taxonomized the strategies that students may use to support comprehension and found these to include strategies that were both cognitive (i.e., paraphrasing and inferencing) and metacognitive in nature (i.e., comprehension monitoring). Elsewhere, Dinsmore and Alexander (2012, 2016) distinguished strategies as either surface- or deep-level in nature. Although surface-level strategies may be considered to be those strategies associated with only the encoding or basic comprehension of information, deep-level strategies are those aimed at manipulating or transforming information for learning. Anmarkrud and Bråten (2009) designed a strategy measure to capture strategies aimed at (a) memorization, (b) organization, (c) elaboration, and (d) monitoring. Memorization strategies corresponded to a desire to recall...
or reproduce information without further transformation and were reflected in items like I made sure that I remembered the most important things. Organization strategies were associated with the ordering or grouping of information and corresponded to items like I tried to create an overview of all of the content in the text. Elaboration strategies were concerned with drawing on information from prior knowledge or from other external sources to improve comprehension and were captured by items like I asked myself questions about the content of the text. Finally, monitoring strategies were associated with the regulation of comprehension and were assessed with items like Now and then I stopped reading to think through or repeat what I had read. Although Anmarkrud and Bråten (2009) included items corresponding to all four of these categories in their strategy inventory, factor analysis found these to reflect to only two dimensions, associated with surface- and deep-level strategy use. Specifically, although the deep-level strategy use factor corresponded to items tapping organization, elaboration, and monitoring, the surface-level strategy factor involved strategies aimed at memorization.

3 | STRATEGIES FOR VIDEO COMPREHENSION

The strategies here described have been focused on the comprehension of information presented via text. Nevertheless, today's students are increasingly expected to make sense of not only information presented via text, but also information presented through other modalities as well, including video (Lenhart, Madden, Macgill, & Smith, 2005; Murphy, Gallagher, Krumm, Mislevy, & Hafter, 2014; Purcell, Heaps, Buchanan, & Friedrich, 2013). Nevertheless, relatively limited work has examined the strategies that may be used to support students' comprehension of information presented via video. Some work has suggested that the same strategies that may be used to derive meaning from text, may also operate to support meaning-making from multimedia sources, including video (Mayer, 2002; Moreno & Mayer, 1999). Specifically, Mayer introduces the selection-organization-integration (SOI) framework to describe learning from expository text and multimedia sources alike (1996; Mayer, 2003). Specifically, Mayer decomposes learning strategies into those associated with (a) selecting important and relevant information to be learned, (b) organizing information into a coherent representation, and (c) integrating new information with prior knowledge, for understanding. Applied to multimedia contexts, selection, organization, and integration strategies can be said to target content presented via an auditory channel (i.e., words), a visual channel (i.e., pictures), or both simultaneously, as is the case with video viewing (Mayer & Moreno, 2002; Moreno & Mayer, 2002).

Mayer and colleagues (Mayer, 1996; Mayer, 2003; Mayer & Moreno, 2002) conceptualize information processed visually or auditorily to be processed using similar strategies, associated with the selection and organization of new information and its integration with prior knowledge. In a complementary model, the Trans-Symbolic Comprehension (TSC) framework, Loughlin and Alexander (2012) instead argue that although some strategies may be common to processing information presented using different symbolic systems (e.g., linguistic versus pictorial), symbol-specific strategies are involved as well. In other words, although information selection, organization, and integration may be processes that operate across symbol systems (i.e., trans-symbolically), symbol-specific processing should be expected as well when students process words vis-à-vis images.

Although trans-symbolic strategies refer to those cognitive processes that are common to encoding or comprehending information presented via any symbol system or modality (e.g., generating inferences), symbol-specific strategies refer to those cognitive processes that are nonuniversal in nature, but rather are specific to particular symbol systems (e.g., interpreting negative space when processing paintings and reducing formulas in mathematics; Loughlin, Grossnickle, Dinsmore, & Alexander, 2015). According to the TSC, within the context of video comprehension, we can expect students to use some strategies specific to video as a modality (e.g., symbol-specific strategies like rewinding), alongside general comprehension strategies (e.g., trans-symbolic strategies like identifying key terms), also invoked during text processing. Although the TSC constitutes a promising framework for understanding strategy use during video viewing, this framework has been empirically investigated or applied to video comprehension only to a limited extent (e.g., List, 2018; List, unpublished; Loughlin et al., 2015).

Magliano, Loschky, Clinton, and Larson (2013) examined students' processing of narrative information across three different media conditions (i.e., text, graphic narrative, and film). Magliano et al. (2013) drew a distinction between the function of front-end and back-end processing across media. Although front-end processing referred to in-the-moment information encoding and extraction (e.g., eye movements and fixations), back-end processing referred to strategies aimed at post hoc comprehension (e.g., inferencing and structure building). Consistent with prior work, Magliano et al. (2013) found students' back-end processing to be consistent across media, whereas front-end processing differed. This is constant with the TSC framework's proposal that although some strategic processes, potentially those associated with comprehension, may be expected to be consistent across mediums, other processes, potentially those focused on encoding, may be expected to be medium-specific. Integrating the front-end and back-end processes specified by Magliano et al. (2013) with Mayer's SOI framework (1996) and Loughlin and Alexander's (2012) TSC, the back-end, meaning-making processes of selection, organization, and integration may be trans-symbolic in nature, whereas strategies for encoding, on the front-end, may be expected to be symbol-specific.

Drawing on these three frameworks, more work is needed to further establish the consistency of strategic processing across text and video. Moreover, particular attention should be paid to strategic processing during the comprehension of expository, rather than narrative information, as has been investigated by Magliano et al. (2013) and Loughlin et al. (2015). In particular, the unfolding nature of story structure may make processing narratives across mediums different from understanding expository information (Berman & Katzenberger, 2004; Best, Floyd, & McNamara, 2008; Graesser, McNamara, & Louwerse, 2003).

As such, the aims of this study are four-fold. First, drawing on the TSC framework, we compare students' strategy use when
comprehending and integrating information presented via two texts vis-à-vis via two videos. Nevertheless, across these modalities of information presentation, we view comprehension uniformly as a meaning-making process, reflecting students’ integration of new information, presented via a variety of symbol systems, with their prior knowledge, and as reflecting a deliberate, goal-directed effort on the part of learners (Kintsch, 1998; Kintsch & van Dijk, 1978).

Moreover, we investigate the consistency of strategy use, by considering whether the same types of strategies are identified when students process two different source of information. Drawing on Mayer’s SOI framework (1996), we specifically examine the extent to which students use strategies aimed at information selection, organization, and integration during processing, in addition to more symbol-specific strategies. As further suggested by Magliano et al. (2013), although these comprehension-focused, back-end strategies may be expected to be common across mediums, front-end strategies, aimed at the more basic encoding of auditory and visual information may be expected to be more symbol-specific in nature (Loughlin & Alexander, 2012).

Beyond looking at the specific strategies that students employ, we also look at the temporal nature of strategy use by examining when, during the course of processing, strategy use emerges. Finally, we examine the comprehension and integration performance according to the conditions of information presentation. As such, we had the following research questions:

1. What strategies do students report using when presented with information via text vis-à-vis via video?
2. What is the association among strategies identified when processing two different sources of information?
3. When during processing, do strategies emerge when students are presented with information via text vis-à-vis via video?
4. What is the nature of students’ comprehension and integration performance when presented with information via text vis-à-vis via video?

4 | METHODS

4.1 | Participants

Participants were 77 undergraduate students enrolled in a university in the Midwestern United States. Participants were, on average, 19.74 years old (SD = 1.39). The majority of the sample was female (63.20%, n = 48; male: 34.20%, n = 26), with two participants reporting their gender as other (2.60%). The sample was majority White (69.70%, n = 53), with 18.40% (n = 14) of participants reporting race/ethnicity as African American, 6.60% (n = 5) as Hispanic, 2.60% (n = 2) as Asian, and 2.60% (n = 2) reporting biracial/multiracial status. Participants represented a range of class standings: 32.90% (n = 25) were freshmen, 19.70% (n = 15) were sophomores, 26.30% (n = 20) were juniors, and 21.10% (n = 16) were seniors. One participant had some demographic information missing.

4.2 | Procedure

First, participants were asked to complete individual difference measures (e.g., prior knowledge and frequency of source use). Then, participants were randomly assigned to either read two texts or to view two videos on the topic of species preservation, with one text/video about penguins and the other about sea turtles. Students were randomly assigned to an information presentation condition (i.e., text or video), with the two topics (i.e., penguins and sea turtles) presented in counterbalanced order.

After reading the two texts or viewing the two videos, participants were asked to annotate each of the sources. Then, participants were asked to complete two post-task comprehension measures, specific to each of the information sources provided, and an integration task, drawing on information presented across the two sources. Data came from a larger project examining video comprehension and integration but unique research questions are investigated in this manuscript (List, 2018).

4.3 | Measures

4.3.1 | Prior knowledge measure

Prior knowledge was assessed by asking participants to respond to six open-ended questions about the two information sources (i.e., penguins and sea turtles). For example, Describe sea turtle breeding or explain what it means when we say penguins are an indicator species. Students’ prior knowledge was scored as correct or incorrect, with total prior knowledge scores ranging from 0 to 6. Average prior knowledge was 2.78 (SD = 1.27) on a 6-point scale, indicating that students constituted a low knowledge sample. Two raters scored 17.95% of students’ responses (n = 14), with a Cohen’s kappa of 0.76, indicating substantial agreement. A one-way ANOVA found no differences in prior knowledge scores across conditions of information presentation, $F (1, 75) = 0.01, p = 0.91, \eta^2_{partial} = 0.00$.

4.3.2 | Information sources

After completing a variety of individual difference measures, all participants were provided with two information sources, one about penguins and the other about sea turtles. Participants were randomly assigned to either the text or video information presentation conditions, either reading the two sources as texts or viewing the two sources as videos.

The two information sources, about species preservation, were drawn from TED-Ed, an online library of animated educational videos. One source, titled “Penguins: Popularity, Peril and Poop,” dealt with historical and contemporary threats to penguins, making them an endangered species (deNapoli, 2013). The other source, titled “The Survival of the Sea Turtle,” covered with life cycle of sea turtles as well as discussing the natural and man-made threats they face (Gass, 2012). Both sources provided expository, factual information about the threats faced by penguins and sea turtles as well as offering some limited solutions to support their preservation.
Videos were selected to be uniform in length, topic (i.e., environmental preservation), and format, as well as to include animations with a voice-over, absent a human narrator. Moreover, videos were chosen from the TED-Ed library because these have a high production value, seem trustworthy, and are designed to be engaging for students; moreover, TED-Ed videos are commonly used in K-12 classrooms (Rubenstein, 2012). In the video condition, participants viewed the two TED-Ed videos. Participants assigned to the text condition were asked to read a transcript of each video. That is, the same linguistic information, following the same organizational structure, was provided to students in both the text and video conditions. Students viewing the two videos had the option to turn on closed captions, if they wanted to, but were not required to do so.

The penguin video was 5.38 min in length (323 s), whereas the sea turtle video was 4.43 min in length (266 s). This corresponded to the penguin text having 767 words and the sea turtle text being 655 words in length. Transcripts were scored for readability, with Flesch reading ease varying from 50.8 to 62.8, for the penguin and sea turtle information sources, respectively; indicating that these were appropriate for use with an undergraduate audience. A reading ease score of 30 or below is considered to reflect the reading level of a college graduate.

4.3.3 | Annotations

After either reading the two texts or viewing the two videos, participants were asked to annotate each of the sources. Specifically, participants were told that the information sources they read or viewed were going to be used to design curricular materials for elementary school students. They were then asked to annotate either the texts or the videos with any questions, comments, or behaviors that may have helped them or may help others to better understand the information provided. Participants in the video condition used a browser-based annotation tool (i.e., VideoAnt, Hosack, 2010; Hosack, Miller, & Ernst, 2009) to add comments to the videos they viewed (See Figure 1). Participants’ annotations, either from Word documents or from the VideoAnt application, were transferred to an Excel file for coding. Locations of the annotations were tagged by word count or according to timestamps in the video condition.

We found assessing strategic processing during video viewing to present a variety of methodological challenges. In particular, approaches often used to capture online processing of text (i.e., verbal reports or think alouds) were found to be incompatible with video viewing. At the same time, we were interested in eliciting a measure of strategy engagement during processing and specifically associating strategy use with particular time points in text and video use. The annotation approach used in this study was adopted to ask students to associate strategies with particular instances of processing texts or videos. Asking students to annotate the texts and videos for younger students was intended to serve as a motivational factor, providing a purpose for the task and to maximize the number of strategies that students reported. Although the annotation measure cannot be interpreted as a valid measure of students’ own strategic processing during reading or viewing, we do believe this was an effective methodological approach to adopt in order to elicit the repertoire or range of strategies that students could identify in association with text and video processing. Strategy knowledge or identification may be considered to be an essential precursor to students’ strategy engagement during any kind of processing (McNamara & O’Reilly, 2009).

4.3.4 | Coding

Participants’ annotations were first coded independently by two raters. Although raters initially looked for students’ reported strategies to correspond to Mayer’s (1996, 2003) SOI framework, many of the strategies that students produced seemed to extend beyond these strategy dimensions. Therefore, a primarily bottom-up coding scheme was adopted. After raters had independently identified strategy categories, these were corroborated between raters, with categories added, collapsed, or removed based on discussion. Once a coding
scheme was finalized, raters recoded participants’ strategies. A total of 13 different annotation categories were included in the final coding scheme. These are described in Table 1, with examples of strategies provided.

Two raters independently scored all student responses. Cohen’s kappa for inter-rater agreement ranged from $\kappa = 0.76$ for the penguin text to $\kappa = 0.85$ for the penguin video. Percent exact agreement was 77.95% and 86.24%, respectively. Cohen’s kappa inter-rater agreement for the sea turtle text was $\kappa = 0.79$ and $\kappa = 0.79$ for the sea turtle video. Percent exact agreement for the two turtle sources was 80.88% and 81.23%, respectively. All disagreements were resolved through discussion.

4.3.5 | Performance

Performance measures assessed both students’ comprehension of each source individually (multiple choice items, open-ended questions) and their integration of the two information sources. Because the primary focus of this study was on identifying patterns in students’ strategy identification across modalities, performance was only examined descriptively across conditions of information presentation, but not in direct association with strategy use.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Strategy coding categories with descriptions and examples</th>
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<tr>
<td><strong>Categories</strong></td>
<td><strong>Description and examples</strong></td>
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</table>
| Low-level strategies | • Restating or slightly paraphrasing information in the sources  
• Asking low-level or “what” questions that could be answered based on content explicitly stated in the information sources, e.g., What are some of the things that make them odd birds? |
| High-level strategies | • Self-explaining or restating information in the sources, with information added to support comprehension  
• Asking high-level or “why” questions that require inferencing and that cannot be answered based on content explicitly stated in the sources, e.g., It is hard to believe that this sort of breeding pattern could have survived the test of time evolutionarily, given that only 10% of the original eggs make it to adulthood. It seems very ineffective, and yet sea turtles are one of the only species still surviving from the dinosaur era. |
| Comprehension strategies | • Identifying challenging vocabulary or asking for definitions of key terms  
• Comments on sentence structure or clarity, e.g., Discuss these types of statements—this idiomatic expression may be difficult |
| Emphasis strategies | • Highlighting  
• Designation certain information as important or as reflecting a main idea, e.g., This video does a good job of laying out the main ideas first and then providing the details that will allow the students to better understand why this idea is true |
| Additional information | • Requests for additional information or further clarification about concepts in the sources, e.g., Maybe mention what other dinosaurs lived during this time to give the kids a reference point |
| Navigation | • Comments about the structure of a source or the order of information presentation  
• Attempts to regulate the sequence of information presentation through rereading text or pausing/restarting a video, e.g., This would be a good section to review, focusing on the birth of sea turtles and their journey to the sea. |
| Reaction | • Affective response; expressions of interest/surprise, e.g., I like this. Really puts everything in perspective and closes the article well. |
| Visuals | • Attending to visual cues or requests that visuals be provided, e.g., Elementary students, or students in general, would benefit from having images that reinforces the text. |
| Summary | • Suggesting that younger students summarize content or students summarizing the content themselves, e.g., At the end of a paragraph: Humans are the main reason for the decline of penguins because of constant disturbances to their homes. |
| Activity | • Recommendation of instructional activities based on information in the sources, including comparing/ contrasting or creating a graphic organizer, e.g., Diagram. The children could work in groups to make a diagram of how a turtle’s lifespan can be/how chances of living decrease over time |
| Application | • Ask students to generalize beyond the information sources, e.g., Again, what can humans do in order to help sea turtles? |
| Evaluation | • Judgment of source trustworthiness or attendance to source information (e.g., TED-Ed, author), e.g., It provides information in a clear, nonbias way, and is likable |
| Prior knowledge | • Activating students’ prior knowledge or comments on their or younger students’ knowledge, e.g., Does anyone know when the Jurassic period was? |

4.3.6 | Comprehension

Comprehension performance was assessed using both multiple choice items and open-ended questions. Participants were asked to complete 10 multiple choice items, with separate questions about content in the penguin and sea turtle sources. For example, participants were asked What percentage of newly hatched baby sea turtles successfully hatch and make it to the ocean and The majority of penguin species live in which climate zone; and provided with four answer options to choose from and the opportunity to select I don’t know. Multiple choice items were scored as correct or incorrect, for a maximum score of 10. Kuder–Richardson’s 20 for the 10-item scale was $\alpha = 0.33$, indicating poor internal consistency. We believe this to be due to a ceiling effect in students’ multiple choice comprehension performance. Specifically, average scores on the multiple choice measure were 7.43 (SD = 1.51); with 54.55% of students receiving scores in the top quartile (i.e., 8–10 points), indicating high performance, overall.

Moreover, in parallel to the prior knowledge measure, participants were asked to respond to six open-ended questions, three about penguins and three about sea turtles. For example, participants were asked: Based on the information presented, please describe the natural threats to sea turtles and Based on the information presented, why have
penguins been historically threatened. Open-ended responses were scored on a graduated scale from zero to two, based on response accuracy and completeness, for a maximum possible score of 12. Two raters coded 21 student responses (26.92%), with Cohen's kappa inter-rater reliability equal to 0.81, indicating almost perfect agreement.

### 4.3.7 | Integration

Integration was assessed by asking students to respond to the prompt *Based on the two information sources, identify the similarities and differences between sea turtles and penguins. What do these two species have in common? What is distinct about them? What did the two information sources have in common? What made them distinct?* Participants’ open-ended responses were scored for the total number of similarities and the total number of differences identified. Responses were counted as a similarity or a difference if they simultaneously and accurately represented a feature of or information from both of the information sources provided. For instance, a similarity identified included students reporting *Both can spend time during their lives both in and out of water and live in aquatic or marine habitats*; whereas a difference identified included *Some differences are that penguins’ prey are a big source for their endangerment while predators are one of the main reasons for sea turtles.* Two raters scored all participant responses for the number of similarities and differences identified, with Cronbach’s alpha reliability equal to 0.76, indicating an acceptable degree of consistency. Discrepancies in scoring were reconciled through discussion.

## 5 | RESULTS

### 5.1 | Research Question 1: Strategy use across conditions

The first research question examined students’ strategy use when presented with information via two texts vis-à-vis via two videos.

<table>
<thead>
<tr>
<th>TABLE 2 Strategies reported across conditions</th>
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<tbody>
<tr>
<td><strong>Text condition</strong></td>
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<tr>
<td>Low-level strategies</td>
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<td>High-level strategies</td>
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<td>Comprehension</td>
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<tr>
<td>Emphasis</td>
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<td>Additional information</td>
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<td>Navigation</td>
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<tr>
<td>Prior knowledge</td>
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<td>Total strategies</td>
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Two-way mixed effects analyses of variance were used to examine the prevalence of each of the five most commonly reported strategies (i.e., low-level strategies, high-level strategies, and strategies associated with comprehension, emphasis, and requests for additional information). Source topic (i.e., penguins or sea turtles) was the within-subject factor and condition of information presentation (i.e., text or video) was the between subject factor. Although only five of the most popular strategies were analyzed via ANOVA, the relative prevalence of all strategies reported, across conditions, is presented descriptively in Table 2.

### 5.1.1 | Low-level strategies

The use of low-level strategies, including asking low-level questions and restating information, differed in association with topic, $F(1, 74) = 6.52$, $p < 0.05$, $\eta^2_{\text{partial}} = 0.08$, indicating a medium effect, per Cohen (1988). Specifically, participants more frequently reported low-level strategy use in association with the penguin source ($M = 1.84, SD = 2.94$) as compared with the sea turtle source ($M = 1.39, SD = 2.36$). However, there were no significant differences across condition of information presentation in low-level strategy use, $p = 0.34$, nor for the interaction between topic and condition of information presentation, $p = 0.21$, identified.

### 5.1.2 | High-level strategies

The use of high-level strategies, including asking deep-level questions or engaging in self-explanation, differed significantly in association with condition of information presentation, $F(1, 74) = 4.20$, $p < 0.05$, $\eta^2_{\text{partial}} = 0.05$, corresponding to a small effect (Cohen, 1988). In particular, participants reported more frequent high-level strategy use when sources were presented as texts ($M = 1.77, SD = 2.64$) rather than as videos ($M = 0.78, SD = 1.29$). Moreover, a significant interaction effect between condition of information presentation and topic was found, $F(1, 74) = 5.38, p < 0.05$, $\eta^2_{\text{partial}} = 0.07$, indicating a medium effect (Cohen, 1988). For the penguin source,
when information was presented via text, more high-level strategies were reported ($M = 0.67, SD = 0.96$) than when information was introduced via video ($M = 0.51, SD = 1.02$). Similarly, the sea turtle source elicited greater high-level strategies used when information was presented via text ($M = 1.10, SD = 1.92$) rather than via video ($M = 0.27, SD = 0.56$). Although a greater number of high-level strategies were reported in association with the textual, rather than video, presentation of each source, across topics, the magnitude of this difference was significantly more pronounced for the sea turtle source. There was no significant main effect for topic, $p = 0.51$.

### 5.1.3 Comprehension strategies

Engagement in comprehension-focused strategies, including considering vocabulary difficulty or sentence clarity, was not found to differ across topic, $p = 0.16$, condition of information presentation, $p = 0.12$, nor in association with their interaction, $p = 0.09$.

### 5.1.4 Emphasis strategies

Students’ use of strategies associated with identifying important information, including highlighting and labeling content as important, was found to differ by condition of information presentation, $F(1, 74) = 8.51, p < 0.01$, $\eta^2_{\text{partial}} = 0.10$, indicating a medium effect (Cohen, 1988). In particular, students presented with the sources via text ($M = 1.97, SD = 3.77$) reported more frequent use of this strategy than did students introduced to the two sources through the video condition ($M = 0.38, SD = 0.72$). There was no significant main effect associated with topic, $p = 0.19$, nor with the interaction between topic and condition of information presentation, $p = 0.31$.

### 5.1.5 Additional information

Requests for additional information differed in association with source topic, $F(1, 74) = 8.19, p < 0.01$, $\eta^2_{\text{partial}} = 0.10$, indicating a medium effect (Cohen, 1988). Specifically, across conditions of information presentation, participants requested more additional information in association with the penguin source ($M = 1.04, SD = 1.40$), than with the sea turtle source ($M = 0.61, SD = 1.34$). However, requests for information did not differ in association with condition of information presentation, $p = 0.26$, nor with the interaction between topic and condition of information presentation, $p = 0.60$.

### 5.2 Research Question 2: Association among strategies identified

The second research question examined the association between the strategies that students identified across sources. In particular, we were interested in the extent to which naming a certain strategy when processing one of the information sources was associated with naming that same strategy, or related strategies, when processing the second information source. A series of chi-square tests were performed to examine the associations among strategies. Alpha was adjusted to account for multiple comparisons ($\alpha = 0.002$). The correspondence of strategies identified across sources is summarized in Table 3.

A binary variable reflecting students’ low-level strategy identification when processing the penguin source was significantly associated with students’ identification of both low-level, $\chi^2(1) = 40.48, p < 0.002$, and high-level strategies, $\chi^2(1) = 10.20, p < 0.002$, when processing the sea turtle source. Likewise, students’ reporting of high-level strategies when processing the penguin source was associated with both high-level, $\chi^2(1) = 11.41, p < 0.002$, and low-level strategy reporting, $\chi^2(1) = 14.35, p < 0.002$, when processing the sea turtle source. Students’ identification of comprehension strategies when processing the penguin source was significantly associated with both low-level strategy, $\chi^2(1) = 21.00, p < 0.002$ and with comprehension strategy reporting, $\chi^2(1) = 15.17, p < 0.002$ when processing the sea turtle source. Finally, identifying strategies associated with emphasizing information when processing the penguin source was significantly associated with naming such strategies when processing the sea turtle source, $\chi^2(1) = 21.08, p < 0.002$. No other associations between strategy categories identified across the two sources were significant ($p ≥ 0.004$).

We were further interested in examining the sequence of students’ strategy use. To do so, we converted students’ strategy use into a series of binary pairs reflecting the engagement of two strategies in consecutive order. For instance, using a low-level strategy, then a high-level strategy, then a comprehension strategy corresponded to two binary pairs (i.e., low→high and high→comprehension). The frequency of students’ sequential strategy engagement, by binary pair, is depicted in Figure 2. Strategy sequences when processing texts vis-à-vis videos are presented separately.

By far, the most commonly used strategy sequence was the paired deployment of two low-level strategies. This was particularly common when students were asked to view two videos (42.34%) vis-à-vis two

### TABLE 3 Associations between strategies identified, across sources

<table>
<thead>
<tr>
<th>Penguin source</th>
<th>Sea turtle source</th>
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<tbody>
<tr>
<td></td>
<td>Low-level strategies</td>
</tr>
<tr>
<td>Low-level strategies</td>
<td>40.48</td>
</tr>
<tr>
<td>High-level strategies</td>
<td>14.35</td>
</tr>
<tr>
<td>Comprehension</td>
<td>21.00</td>
</tr>
<tr>
<td>Emphasis</td>
<td>21.08</td>
</tr>
</tbody>
</table>

Additional information

Note. Chi-square values that are significant at the $\alpha = 0.002$ are included in the table; blank cells indicate a non-significant association. Alpha value was determined by dividing $\alpha = 0.05$ by 25, reflecting the number of comparisons carried out.
texts (14.25%). Consecutive comprehension and emphasis strategies were also commonly used across the two conditions. These strategy sequences were more common for the text rather than the video conditions. In particular, 16.71% of strategy pairs in the text condition reflected consecutive comprehension strategy use, as compared with 5.84% of strategies in the video condition. Likewise, 12.60% of strategies used in the text condition reflected paired emphasis strategy use as compared with 0.36% of strategies in the video condition. Although these results reflect patterns in the overall prevalence of different strategies engaged, they also reflect the need to further examine strategy engagement in terms of its sequence during processing.

5.3 Research Question 3: Distribution of strategy annotations throughout processing

The third research question examined strategy identification as it unfolded during the course of reading the two texts or viewing the two videos. For this research question, we were not interested in which strategies students identified, but rather when strategies were reported during processing. Texts and videos were segmented into quintiles according to word count or seconds, respectively. As such, for both the penguin and the sea turtle sources, students had five scores corresponding to the number of strategies they reported in each quintile of each source’s duration.

A three-way (2 × 5 × 2) mixed-effects ANOVA was run. Topic (i.e., penguin and sea turtle) and quintile (i.e., first, second, third, fourth, and fifth) were entered as within subject factors and condition (i.e., text and video) was entered as the between subject factor. First, main effects were examined. There was a significant main effect for topic, $F(1, 75) = 4.13$, $p < 0.05$, $\eta^2_{partial} = 0.05$, reflecting a small effect (Cohen, 1988). This indicates that students produced significantly more annotations in association with the penguin source ($M = 6.92$, $SD = 4.06$) as compared with the sea turtle source ($M = 6.21$, $SD = 3.67$). A main effect for quintile was also identified, $F(1.95, 145.87) = 10.59$, $p < 0.001$, $\eta^2_{partial} = 0.12$, using Greenhouse–Geisser correction for a violation of sphericity. This reflected a medium effect, according to Cohen (1988). Post hoc analyses using paired sample $t$ tests determined that significantly more annotations were produced in the first quintile ($M = 3.74$, $SD = 3.03$) than the remaining quintiles (second quintile: $M = 2.43$, $SD = 1.79$; third quintile: $M = 2.53$, $SD = 1.92$; fourth quintile: $M = 2.35$, $SD = 2.02$; fifth quintile: $M = 2.06$, $SD = 1.53$). Additionally, students reported significantly more annotations during the third quintile ($M = 2.53$, $SD = 1.92$) than they did during the fifth quintile ($M = 2.06$, $SD = 1.53$). Further, a main effect for condition was identified, $F(1, 75) = 13.21$, $p < 0.001$, $\eta^2_{partial} = 0.15$, a large effect, such that students reported significantly more annotations in association with the text condition ($M = 15.21$, $SD = 7.96$) than they did in association with the video condition ($M = 10.60$, $SD = 8.72$).
The two-way interaction between topic (i.e., penguin or sea turtle) and quintile was not significant, \( p = 0.24 \). Likewise, the two-way interaction between condition of information presentation and quintile was also not significant, \( p = 0.27 \). However, there was a significant three-way interaction between topic, condition of information presentation, and quintile, \( F(4, 75) = 2.76, p < 0.05, \eta^2_{\text{partial}} = 0.04 \), reflecting a small effect (Cohen, 1988). This interaction is displayed in Figures 3 and 4.

A stacked bar graph was also created to reflect this interaction and to represent the distribution of students' reported strategies by quintile. The percent of strategies reported within each quintile by source and condition of information presentation is depicted in Figure 5. As can be seen in Figure 5 across topics and conditions of information presentation, strategies were most frequently reported at the beginning of processing. Most strategies were reported during the first quintile of each source, whereas the second most frequent strategy was reported during the second quintile.

**Figure 3** Three-way interaction between topic, condition of information presentation, and quintile for the penguin source [Colour figure can be viewed at wileyonlinelibrary.com]

**Figure 4** Three-way interaction between topic, condition of information presentation, and quintile for the sea turtle source [Colour figure can be viewed at wileyonlinelibrary.com]
reporting of strategies was associated with the second quintile. This front-loading of strategies was particularly prevalent for the two video sources. For instance, although 22.01% of strategies were reported during students’ reading of the first quintile of the penguin text, a percentage roughly proportionate to the amount of information was covered; 36.45% of strategies were reported during the first quintile of the penguin video. The disproportionality in the volume of strategies reported relative to the amount of content presented is particularly clear by examining strategy reporting in association with the fifth quintile of each information source. Again, examining the penguin text vis-à-vis the penguin video, 19.18% of strategies were reported during students’ reading of the last quintile of the penguin text; however, only 11.68% of strategies were reported in association with the final quintile of video viewing. Similar patterns were found between processing of the sea turtle text vis-à-vis the sea turtle video.

5.4 | Research Question 4: Performance across modality condition

For the fourth research question, descriptive statistics of performance across conditions of information presentation are shown in Table 4. In particular, participants assigned to the video condition performed better on the comprehension assessment (i.e., multiple choice: $M = 7.50$; open-ended: $M = 8.29$) as compared with participants assigned to the text condition (i.e., multiple choice: $M = 7.35$; open-ended: $M = 7.67$). As a contrast, in terms of integration performance, the number of similarities ($M = 3.77$) and the number of differences ($M = 1.33$) produced by participants in the text condition were higher than the number of similarities and differences produced in the video condition (similarities: $M = 3.21$; differences: $M = 1.24$).

6 | DISCUSSION

In this study, participants were presented with two sources on the topic of endangered species, one about penguins and the other about sea turtles. Moreover, modality of information presentation was varied such that students were randomly assigned to either view these two sources as videos or to read the two sources as texts. During processing, students were asked to annotate these sources. Annotations were coded for evidence of strategy identification. Finally, students were asked to complete measures of comprehension and integration based on information presented across the two sources. We were interested in the strategies that students reported across the two different task conditions (RQ1), the association among the strategies that students identified across sources (RQ2), and when, during processing, strategies were reported (RQ3). We also examined differences in comprehension and integration performance across modality conditions, to contextualize the performance context within which students’ strategy reporting was situated (RQ4).

This study contributes to the literature in at least four ways. First, we are among the first to compare text and video processing. To this end, rich process data were collected in the form of text/video annotations. Moreover, we examined performance measures reflecting not only the comprehension of information sources individually, but also their integration. As such, this is among the first investigations to examine integration within the context of video processing and to consider the extent to which students’ integration of information presented across videos may be similar to or different from their integration of information presented via texts. Third, we use an
innovative task to capture strategic processing. Specifically, the task induction asked participants to report the comments, questions, or behaviours that they would use to help younger students understand the information sources provided. In doing so, participants were asked to annotate the text or video sources using the track changes feature in Microsoft Word, for the text condition, or a browser-based application, VideoAnt, for the video condition. Among the advantages of this methodological approach is the ability to collect time-series data, with strategies reported in association with particular time points in text and video processing. Fourth, in addition to examining when during source use strategies were reported, we also considered students’ comprehension and integration performance when either reading texts or viewing videos.

6.1 | Research Question 1: Strategy use across conditions

The first research question examined differences in strategy identification across condition of information presentation, with sources presented either as texts or as videos. Following Mayer’s multimedia comprehension framework (2002, 2005), we were first interested in the extent to which students reported strategies associated with (a) selecting important information, (b) organizing information, and (c) integrating information across modalities (i.e., auditory and visual) and with prior knowledge. Among these, strategies associated with selecting important information were most commonly reported, termed emphasis strategies in the present analyses. These were efforts by students to recognize key content, labeling it as important, or to identify content to revisit, through highlighting. Across the two information sources, a total of 26.40% of the strategies reported reflected students selecting or emphasizing important information. Organization strategies were reported more rarely and often times suggested, but not necessarily engaged by students. For instance, one student recommended creating a table based on source content, reporting Present these “steps” as a timeline and put it side by side with the hypothetical example at the end. Nevertheless, this student did not actually evidence creating such a table during the course of processing. Integration strategies were reflected in our study in two ways. Cross-modal integration was evidence through students’ attendance to visuals, in the video condition, and students’ expressing a desire to have visuals to aid in comprehension, in the text condition. Strategies coded into the visuals category constituted 2.09% of the total number of strategies reported for the penguin source, and 4.79% of the strategies reported for the sea turtle source, indicating their low prevalence, overall. Integration of content with students’ prior knowledge was likewise reported only to a fairly limited extent (penguin source: 2.27%; sea turtle source: 1.15%).

Generally speaking, students used more strategies during text processing than video processing. This is constant with Loughlin et al.’s (2015) TSC framework, which predicts that there would be both similarities (i.e., trans-symbolic) and differences (i.e., symbolic-specific) in students’ strategic processing across modalities. Interestingly, the strategies that students reported more often using in association with the text condition were generally, higher-level in nature. These included a greater number of emphasis strategies, associated with selecting important information and high-level strategies, including engagement in self-explanation, reported.

This may have been the case for a number of reasons. To start, students may have had more experience using high-level strategies in association with text processing, rather than with video viewing, given the dominance of text in school curricula (Alexander & Disciplined Reading and Learning Research Laboratory, 2012; Anderson, Hiebert, Scott, & Wilkinson, 1985; Chall, 1983). Moreover, because information presented via video likely required students to pause in order to engage strategies, identifying certain strategies, like self-explanation, may have been perceived by students as disruptive to processing (Mu, 2010). Conversely, given students’ generally favorable comprehension performance in the video condition, it may have been the case that students did not think they needed to report the same degree of strategy engagement during video processing that they did during reading. This is particularly evidenced by strategies associated with visuals being more frequently reported in association with the text condition. Students in the video condition may not have needed to request visual representations of information, as such visuals were provided in the videos. Indeed, the inclusion of visual information in video may have aided students’ comprehension, improving performance overall. In fact, in some cases, strategies coded into the visuals category for students in the video condition reflected students expressing how helpful or interesting they found the visuals to be.

6.2 | Research Question 2: Association among strategies identified

The second research question examined the association among strategies reported when students processed the penguin source vis-à-vis the sea turtle source. A number of conclusions may be drawn from these analyses. First, the strategy categories that students reported across sources were largely consistent with one another. For instance, when students identified comprehension-related strategies when processing the penguin source, they also named such strategies when processing the sea turtle source. Given that the two information sources were purposefully selected to parallel one another, a consistency in processing may be expected. Second, the identification of low-level and high-level strategies was associated with one another across sources. This suggests that there may be a general strategic engagement factor in place. This may mean that students who are actively engaged in processing sources, use both low-level and high-level strategies in conjunction with one another, rather than employing one strategic approach over the other. This seems consistent with Pressley and Afflerbach’s (1995) account of comprehension as a deliberate, active, and engaged meaning-making process. The identified association between low-level and high-level strategies, documented in this study, suggests that such strategies cannot be easily separate one from the other, as they have been in some prior work (Dinsmore & Alexander, 2012, 2016). Moreover, Dinsmore and Zoellner (2018), in a recent examination of strategy use, found surface-level, deep-level, and metacognitive strategies to be separate predictors in a model of performance, with metacognitive strategy...
use predicting both surface- and deep-level strategy use. Moreover, in a follow-up small spaces analysis, they found that although higher performing students were more likely to employ multiple types of strategies to iteratively improve their understanding of a climate change simulation, lower performing students exhibited more limited strategy use and over-generalized conclusions based on manipulations of a single variable (or the deployment of a single strategy). Although findings from Dinsmore and Zoellner (2018) echo our results identifying a relation between surface- and deep-level strategy use, they indicate the need to further examine how students belonging to different performance profiles may differ in their strategy engagement.

As an additional point, results examining the sequence of strategy use suggest that students adopting a particular type of strategic approach (e.g., low-level or comprehension strategy use) were likely to use this approach in sequence. Moreover, students in the text condition more commonly engaged strategies associated with comprehension or emphasis, whereas students in the video condition were more likely to rely on low-level strategy use. Although the sequential analysis conducted in response to this research question was only preliminary in nature, further examining patterns in students' strategy use constitutes an important area for future work.

6.3 Research Question 3: Distribution of strategy annotations throughout processing

The third research question examined when strategies were identified during the course of processing. An intriguing finding to emerge from this analysis may be that the difference in strategic processing across conditions of information presentation may be not in what strategies are used during processing, but may be in when strategies are deployed.

We found that although strategy identification generally decreased during the course of processing, this decrease was particularly pronounced for the video condition. There may be a number of explanations for this effect. For one, cognitive load theory suggests that the multimedia features associated with video presentation may overtax students' working memory resources, decreasing students' degree of strategic engagement during the course of video processing (Mayer & Moreno, 2002). This explanation is further supported by there being more strategies reported, overall, during text processing than there were during the processing of videos. An alternative explanation may be that the immersive nature of video draws students in, reducing the degree of purposeful processing engaged during the course of video viewing (Sherer & Shea, 2011). As such, the immersive nature of video may serve a seductive or distracting function, interrupting deep-level processing, or may aid comprehension by better drawing students' attention to video content. This latter explanation seems better supported, given evidence that students generally performed better in the video condition vis-à-vis the text condition on questions of comprehension. As an additional point, given the moderate difficulty of the videos used in this study and their instructional quality, it may have also been the case that during the course of viewing, students decided that they did not need to engage in the deep-level processing of these materials, given that they were able to comprehend them with relative ease. Finally, frontloading strategies towards the beginning of material to be processed, as was evidenced in the video viewing condition, may be an adaptive strategy for learners that allows them to better process subsequent content with greater ease. More work is needed to understand the role that strategy use generally, vis-à-vis the temporal distribution of strategies, plays in performance.

6.4 Research Question 4: Performance across modality condition

Research question 4 examined differences in task performance across the text and video conditions. Comprehension performance was found to be stronger in the video condition, whereas integration performance was higher for students in the text condition. This suggests the importance of examining the features of performance outcomes when making determinations of the differences between the effectiveness of information presentation via videos vis-à-vis via texts. In particular, it may be the case that, as suggested by the Mayer's cognitive theory of multimedia learning, the presentation of information via video is, indeed, associated with improved comprehension performance. Nevertheless, deeper-level processing and elaboration, associated with integration performance, may be improved by the presentation of information via text. More work, beyond this preliminary study, is needed to examine the association between strategy use and both comprehension and integration performance. In this study, we were interested in systematizing the strategies that students identified in association with processing texts and videos. This in-depth examination was necessary given the nascent literature on video processing and allowed us to examine strategy reporting during the course of processing (i.e., throughout reading or viewing). At the same time, the volume of strategies that we catalogued did not readily allow us to associate these with task performance, a necessary next step in further investigations.

6.5 Implications

Examining results across research questions, at least three key implications may be drawn. First, drawing on results from the first research question, students may need more support to engage in strategy use during video viewing vis-à-vis during reading. In particular, asking students to identify important information or main ideas in video and cuing other deep-level strategy use may be important strategies for teachers to incorporate into their instruction. Second, prompting strategic processing, generally, may increase students' engagement of both surface-level and deep-level strategies, given that these were found to be associated in Research Question 2. Third, as indicated in the distribution analyses conducted for Research Question 3, students may need particular support to engage strategy use throughout and towards the end of processing, as demonstrated by their front-loading of strategic engagement. Asking comprehension or integration questions following video viewing may be a viable strategy for encouraging students to more deeply process information throughout reading or viewing.
6.6 | Limitations and future directions

Despite the innovative nature of the study, some limitations must be acknowledged. First, students reported a large variety of strategies during processing and, although we attempted to collapse the strategies that students used into theoretically-determined categories (e.g., surface-level vs. deep-level, Dinsmore & Alexander, 2012, 2016) this proved to be a difficult task. Indeed, identifying strategy engagement in students’ annotations required interpretation on the part of researchers. Future studies should consider different approaches either to strategy assessment or to strategy analysis to better identify patterns in students’ strategy use. One approach may be to ask students themselves to classify the strategies they reported using according to their aims (e.g., understanding the text and applying information in text). Another approach may be to ask experts in strategy use or comprehension to classify the strategies that students reported engaging.

Dinsmore and Alexander (2012) argue that differences in prior knowledge or domain expertise correspond to differences in strategy use among learners. In particular, aligned with the Model of Domain Learning (Alexander, 2003), they argue that although the strategy use of novice students in the acclimation stage of domain learning may be expected to be predominantly surface-level in nature, the strategy use of students in competency or proficiency would shift to be more deep-level in nature. As the students in our sample were low in prior knowledge, surface-level strategies were expected to dominate; nevertheless, the role of prior knowledge in strategy use when learning from different modalities remains a key area for investigation.

As a secondary point, to assess students’ strategy use in this study, we asked them to annotate sources to help younger students better understand the information in the sources provided. A strength of this methodological approach was that it provided a naturalistic purpose and a motivation for reporting strategies. At the same time, this approach carried with it a number of limitations. For instance, participants may have annotated the sources with strategies that they believed to be helpful for younger students but that they themselves did not use during processing; conversely, students may have under-reported certain strategies that they themselves engaged because they considered these to be inappropriate for younger learners. As such, this task manipulation limits the inferences that can be drawn about students’ strategic processing during reading and video viewing, and their reported annotations. More generally, prompting students to report strategies, especially directed toward younger students, may have resulted in over-reports of strategy use. Nevertheless, we thought this induction was a viable method of assessing students’ strategic repertoire when processing texts and videos and was a methodological approach that was transferable across modalities, as compared with think-aloud and other verbal report approaches that were incompatible with video processing.

Moreover, the annotation task occurred after students had already been presented with each of the information sources, meaning that the strategies that students initially engaged may not have carried over to their annotation of sources upon a second presentation. During the video condition, in particular, strategic reporting may have suffered due to students’ immersion in the videos they were viewing (Merkt, Weigand, Heier, & Schwab, 2011), with annotating videos requiring that students pause or interrupt the playback of information.

In this study, we only examined strategy identification across two modalities of information presentation (i.e., text and video). Further work is needed to compare students’ comprehension and integration when information is presented via video versus via text with images, reflecting a static presentation of video content; and via video versus via audio, tapping the auditory channel used during video processing, but absent any visual information provided. There are also a variety of individual difference measures not examined in this study that may, nevertheless, have a bearing on students’ strategic processing. These include reading comprehension, motivation for task completion, and students’ degree of metacognition (Afflerbach et al., 2008; Pintrich, 2004).

As a final point in this study, we were interested in examining strategy reporting beyond counts of the strategies that students engaged or not. To this end, we examined the temporal distribution of strategies during processing and the association among strategies used across sources. Further work is needed to examine more overarching patterns in strategy use or to create profiles of strategy engagement. Latent profile analysis may be a promising method of detecting underlying profiles in students’ strategy use (Dinsmore & Zoellner, 2018). The consistency of such profiles across modalities of information presentation also remains as a question for future work.

7 | CONCLUSION

In this study, we asked students to process two texts or two videos and to annotate these with the strategies that they used or would recommend that others use during processing. As suggested by the TSC framework (Loughlin et al., 2015), strategies were found to be differentially identified across modalities of information presentation, with more strategies used during text processing, as compared with video viewing. Additional patterns were identified in students’ strategy reporting across modalities. For instance, students tended to front-load strategies towards the beginning of processing, a pattern that was particularly pronounced in the video condition. And strategies identified were consistent when processing two different sources, across modalities of information presentation. In other words, using low-level strategies when processing a source about penguins was associated with using such strategies when processing a source about sea turtles; and this association was consistent regardless of whether information was presented via text or via video. In terms of performance, students assigned to the video condition seemed to perform better than students in the text condition on comprehension outcomes, with the reverse pattern identified for integration performance. A necessary next step for investigation requires directly associating strategy use and performance across modality conditions.

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