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EFFECTS OF EXPANDED AND STANDARD CAPTIONS ON DEAF COLLEGE STUDENTS' COMPREHENSION OF EDUCATIONAL VIDEOS

TWENTY-TWO COLLEGE STUDENTS who were deaf viewed one instructional video with standard captions and a second with expanded captions, in which key terms were expanded in the form of vocabulary definitions, labeled illustrations, or concept maps. The students performed better on a posttest after viewing either type of caption than on a pretest; however, there was no difference in comprehension between standard and expanded captions. Camtasia recording software enabled examination of the extent to which the students accessed the expanded captions. The students accessed less than 20% of the available expanded captions. Thus, one explanation for the lack of difference in comprehension between the standard and expanded captions is that the students did not access the expanded captions sufficiently. Despite limited use of the expanded captions, the students stated, when interviewed, that they considered these captions beneficial in learning from the instructional video.

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As mandated by law, virtually all television programs may now be viewed with captions. These captions are a text display of the audio component of the television program, which is generally displayed at the bottom of the television screen (Lewis & Jackson, 2001). Captions may be open, where everyone viewing the video sees the captions, or closed, where the viewer must set the closed-captioned decoder, which is contained in virtually all television sets, so that it displays captions. A major reason for the production of captions is to provide deaf people access to the audio component of television programming. (The term *deaf* is used in the present article to refer to the full range of individuals with hearing loss, including members of the Deaf culture.) Producers of captions and educators have both been concerned whether individuals who are deaf are able to understand captions that are presented at relatively fast speeds (e.g., greater than 140 words per minute) and that sometimes contain complex grammatical forms. This concern is based on the limited reading proficiency of many persons who are deaf (Ward, Wang, Paul, & Loeterman, 2007).

A number of investigators have examined ways to modify captions to improve deaf individuals' comprehension of videos. Some research on the effects of captions on comprehension has focused on whether the captions have been edited to delete information viewed as nonessential and to simplify grammatical structure (Baker, 1985; Braverman & Hertzog, 1980). Other research has examined the speed at which captions are presented, and the association between reading proficiency and comprehension (Burnham et al., 2008). Studies on the effects of editing captions to reduce linguistic complexity have obtained mixed results. Braverman and Hertzog (1980) found, with college students, and Baker (1985), with deaf children, that reducing language complexity increased comprehension of a television program. In the Baker study, the editing of captions was accompanied by a reduction in the caption presentation rate so that it was not clear whether rate or language complexity was the primary factor that accounted for the results. In contrast, Ward et al. (2007) did not find with children, and Burnham et al. (2008) did not find with adults, that reducing linguistic complexity increased (or decreased) comprehension of captions.

Two studies examined effects of caption rate on comprehension. These studies indicated that rate either has no effect on comprehension or that variation in rate only affects selected readers. Braverman and Hertzog (1980) found that rates of 60, 90, and 120 words per minute did not differentially affect comprehension by students. Burnham et al. (2008), in contrast, found that rates of 130, 180, and 230 words per minute selectively affected participants' comprehension, depending on the reading proficiency of the participants. Slower caption rates tended to facilitate the comprehension of more proficient readers, but this was not the case for less proficient readers.

Another factor that may increase deaf students' comprehension of captions is expansion of the amount of information available in the captions. Fels (2002) and Silverman and Fels (2002) suggested that nonverbal information, including shapes, colors, symbols, and animation, increases deaf individuals' comprehension when used with captions. For example, use of speech bubbles and different text styles may help captions convey the emotions of different speakers. In addition, captions may be made interactive through use of hyperlinks to provide optional definitions, background information, related material, or an instructional exercise (Treviranus, 2000).

Anderson-Inman, Terrazas-Arellanes, and Slabin (2009) investigated whether use of expanded captions increased comprehension of captioned educational videos with biology content by nine deaf students in grades 6–12. Expanded captions might deepen the value of educational videos by linking important words that are likely to be unfamiliar in the captions to one of three kinds of additional information: vocabulary definitions, labeled illustrations, or concept maps. Anderson-Inman et al. (2009) described each of these types of information in the expanded captions as a form of eText support; eText is digital text that is modified to facilitate the reader's comprehension or learning of a text (Anderson-Inman, 2009).

Anderson-Inman et al. (2009) compared gains in learning from a pretest to a posttest when students viewed a video with expanded captions in which they could access additional information and when they viewed a video with standard captions. Tests for statistical significance indicated that students did not retain more information when viewing expanded captions than when viewing standard captions. Furthermore, students did not perform better on posttests than on pretests for either condition.

One reason that Anderson-Inman et al. (2009) did not find differences between performance on the pre- and posttests for either the expanded or standard captions may have been that the students did not have a sufficiently high reading level (a) to benefit from these captioned materials in general, and (b) to benefit more from the expanded captions than from the standard ones. Previous research had found that deaf students who are more proficient readers benefit more from captions than students who are less proficient readers (Burnham et al., 2008; Lewis & Jackson, 2001).

The present investigation followed up on the Anderson-Inman et al. (2009) investigation by using the same materials used by Anderson-Inman et al. with deaf college students in order to determine whether these students, who have more academic experience and higher reading proficiency, would benefit from the captions. This investigation addressed three questions:

1. *Do deaf college students learn from viewing a captioned instructional video, as indicated by a pretest-to-posttest increase in performance?* This question pertained to student gains in test performance regardless of whether the captions were standard or expanded.
2. *Do student learn more when they view expanded captions than when they view standard ones, as indicated by a greater pretest-to-posttest increase in performance for the expanded captions than for the standard ones?*

3. *How did students perceive their experiences with the standard and expanded captions?* The study included qualitative interviews to identify students' perceptions of what was desirable and undesirable in each kind of caption, information that might help with interpretation of the quantitative results as well as yield suggestions for improving the expanded captions.

Method

Design

All participants underwent each of the experiment's two treatment conditions: (a) standard captions and (b) expanded captions (Shadish, Cook, & Campbell, 2002). For standard captions, there were two videos with different content, and each of these had a corresponding video for expanded captions. Students were randomly assigned to a combination that counterbalanced video content, treatment, and presentation order across participating students. This counterbalancing controlled for confounding of treatment with video content and associated tests and with order of presentation.

Participants

Twenty-two volunteers attending a university in the northeastern United States participated in the present study. Participants were recruited through flyers posted throughout the campus asking for students who were deaf or hard of hearing. The study had received approval of the university's institutional review board, and students completed a letter of consent prior to participation. Table 1 provides demographic information about the students; pseudonyms were used to protect confidentiality. Twelve of the students were female and 10 were male. Students' level of hearing loss ranged from profound in both ears (n = 11) to mild in both ears (n = 1). The mean ACT English score was 16.13 (percentile equivalent = 25%, American College Testing, 2011), and the mean ACT Reading score was 19.88 (percentile equivalent = 47%). These data indicate that these students were relatively proficient readers compared to the general population of deaf readers. The mean reading percentile score of 47 for the deaf students in this study was close to the midpoint in the ACT norms, which are based on hearing students. In contrast, the mean reading comprehension score in a nationwide survey of deaf students at grade levels 10–12 was substantially lower (slightly above the 18th percentile in the National Longitudinal Transition Study on the Woodcock-Johnson Tests of Academic Achievement, norms from hearing students; Wagner, Newman, Cameto, & Levine, 2006; Walter, 2010; Woodcock, McGrew, & Mather, 2001).

Students ranged in age from 17 to 26 years, with a mean age of 21.45. Data were available for 11 participants regarding their use of amplification. Four used a cochlear implant, 3 used two hearing aids, 2 used one hearing aid, and 2 did not use amplification. With respect to ethnicity, of the 20 students for whom data were available, 2 were African American, 1 was Asian, 1 was Hispanic, and 16 were White. For some students, certain data were not available (NA). This information was drawn from student records at the university.

Intervention

The present study used expanded captions in which preselected vocabulary words were linked to one of three types of additional information: glossary definitions, labeled illustrations, and concept maps. In addition, expanded captions provided a way for learners to interact with, and study, the video's content. The three types of expanded captions represented three different ways in which key vocabulary was supported to improve comprehension. "Translational resources" were key vocabulary words in captions linked to definitions for "translating" unfamiliar words into a word or words that were more familiar to the learner (Anderson-Inman & Horney, 2007). Translations included synonyms for identified words, and longer definitions that explained their technical meaning. "Illustrative resources" were key vocabulary words linked to labeled illustrations (Anderson-Inman & Horney, 2007). Illustrative resources provided visual images of concepts or processes. For these types of expanded captions, the video stopped and the resulting image in a separate window was labeled, by means of arrows, directing attention to the concept or process linked with the vocabulary word. "Summarizing resources" were key vocabulary words linked to concept maps (Anderson-Inman & Horney, 2007). Summarizing resources provided an overview of some aspect of the content under instruction—in this case, the taxonomic system used to describe the biological structure of life. When accessing a window with the additional information, the student could not view the display of the original educational video and accompanying captions; the student clicked on the Back button (or pressed Enter) to return to the original display of video and captions.

Materials

Videos and Captions

Three 20-minute educational videos from the series *Branches on the Tree of Life* (www.ebiomedia.com/vmchk/Branches-on-the-Tree-of-Life), by BioMEDIA Associates, were used in the research for the present study, one for training and two for the experimental

Table 1
Student Characteristics

Student[a]	*Gender*	*Hearing loss, left ear*	*Hearing loss, right ear*	*ACT Reading score*	*ACT English score*	*Age (years)*
Abiel	F	Profound	Severe	NA	NA	20
Breanna	F	Profound	Profound	13	15	24
Abigail	F	Severe	Profound	21	21	22
Ryan	M	Profound	Profound	21	17	19
Stephanie	F	NA	NA	36	29	19
Erika	F	Profound	Profound	19	9	18
Jamie	F	Profound	Severe	15	11	24
Andrew	M	Profound	Profound	NA	NA	26
Mona	F	Profound	Profound	20	19	18
Keith	M	Profound	Profound	0	0	24
Brian	M	Profound	Profound	0	0	22
Blake	F	Profound	Profound	19	13	20
Breanna	F	Severe	Severe	26	23	20
Tom	M	Profound	Profound	18	14	19
Patrick	M	NA	NA	22	15	23
William	M	Moderate	Moderate-severe	21	17	19
Nathaniel	M	Profound	Profound	23	16	22
Sean	M	Mild	Mild	NA	NA	24
Caitlin	F	Profound	Profound	13	10	25
Brittany	F	NA	NA	NA	NA	17
Kiera	F	NA	NA	13	18	24
James	M	Profound	Severe	18	11	23

[a] Pseudonyms were used to protect confidentiality.

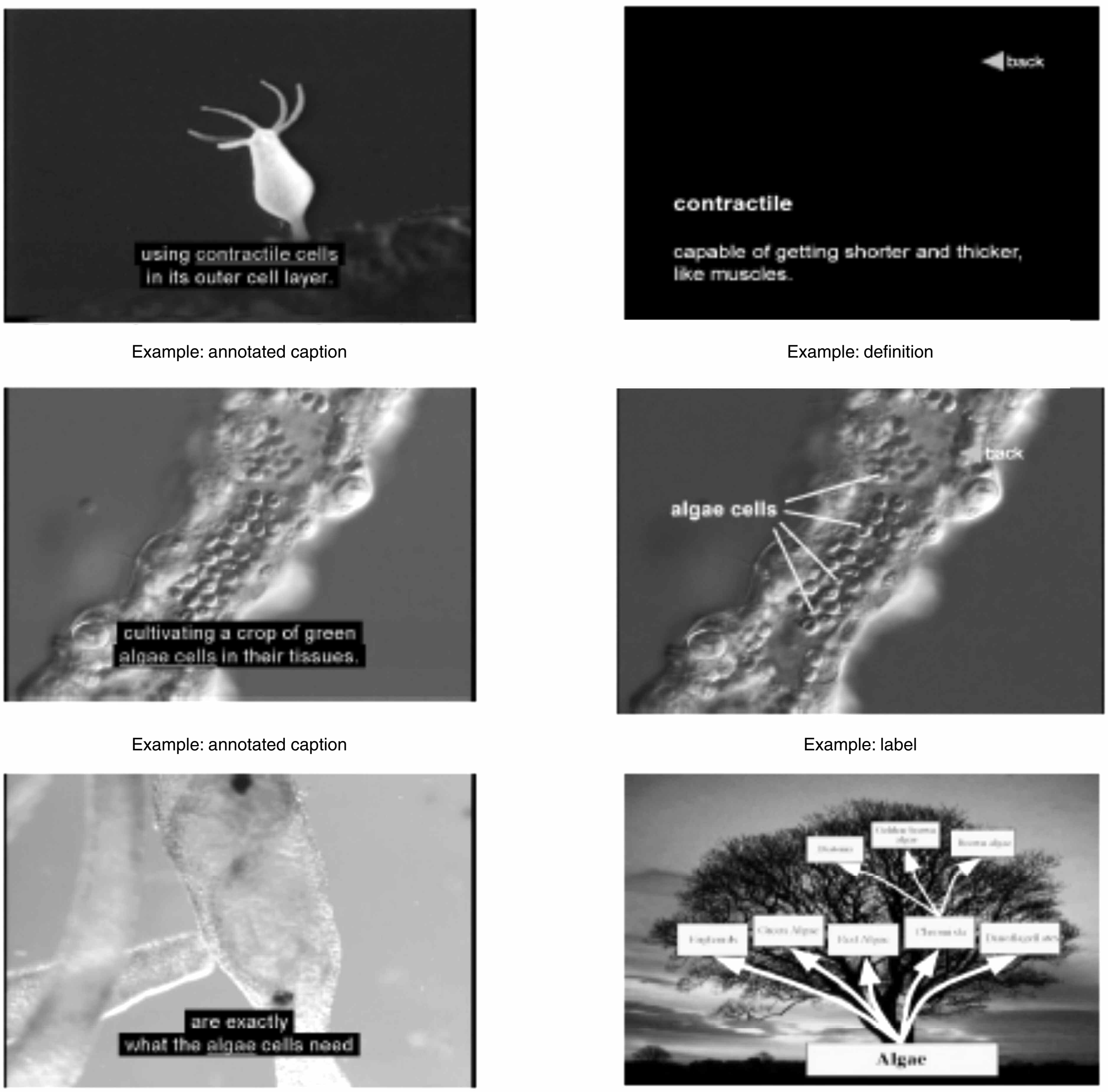
treatments. These materials already had standard captions, developed by CaptionMax, a large media access company in the United States. CaptionMax selected the specific videos from the *Branches* series using the following criteria: (a) 15–20 minutes in length, (b) content independent of other videos, and (c) content not generally known by average secondary students. To create expanded captions, Anderson-Inman et al. (2009) identified key terms in these videos that might be problematic for students and decided how best to support learning of the concept. This process led to the three types of expanded captions described above. Each of these three is described below and illustrated in Figure 1.

Vocabulary definitions were the most common type of expanded caption. Key content words in the captions were highlighted in green. When students clicked on the highlighted word (or pressed Enter), a new window appeared. The window repeated the target word, followed by a definition tied to the word's use in the video. Clicking the Back button (or pressing Enter again) returned viewers to the video segment with the original captioned sentence still on the screen. The video then continued playing until the student clicked on another highlighted word to access the additional information for that word.

Labeled illustrations directed attention to specific features illustrated in the videos. When students clicked on the highlighted word, the image froze, and text with arrows drew attention to the target concept. Pressing Enter returned viewers to the video with the original captioned sentence.

Concept maps depicted the relationship of targeted organisms within biology's hierarchy of eight major taxonomic ranks: species, genus, family, order, class, phylum, kingdom, and domain. These relationships were an important conceptual element in the *Branches of the Tree of Life* video series. When understanding one of these distinctions seemed to be the focus of the video, a concept map in the expanded caption showed the organism on a "tree" in relationship to other concepts of the same or neighboring taxonomic level. When students clicked on the highlighted word, a new window appeared containing a concept map that zoomed in on the targeted organism and then zoomed out.

Figure 1
Screen Shots Illustrating Annotated Captions (on the left) and the Corresponding Three Types of Expanded Captions (on the right)



Example: annotated caption

Example: definition

Example: annotated caption

Example: label

Example: annotated caption

Example: concept map

Note. From "Supported eText in Captioned Videos: A Comparison of Expanded Versus Standard Captions on Student Comprehension of Educational Content," by L. Anderson-Inman, F. E. Terrazas-Arellanes, and U. Slabin, 2009, *Journal of Special Education Technology*, 24(3), pp. 25–26. Copyright 2009 by Exceptional Innovations. Adapted with permission.

Clicking the Back button (or pressing Enter again) returned students to the video with the original captioned sentence.

The difference between the videos with standard captions and the ones with expanded captions is that in those with standard captions, none of the words were highlighted and there were no separate windows with additional information. In contrast, the videos with the expanded captions (a) had highlighted words among the captions for the educational video and enabled users to click on these words, and (b) required users to access the additional information in a separate window (e.g., vocabulary definitions).

Instrumentation

Information on student use of the videos and its impact on comprehension was measured in three ways: (a) pre- and posttests on important concepts in the videos, (b) screen-capture recordings of students' interactions with the videos, and (c) an exit interview on students' reactions to the expanded captions. The present study used the same three sets of pre- and posttests (one set for each video) used by Anderson-Inman et al. (2009) to measure students' comprehension of the vocabulary and informational content of the videos. Each test consisted of 10 multiple-choice questions, and each question had three response alternatives. Each set of pre- and posttests had the same items, with the items ordered differently in the two versions by random assignment. In addition, response alternatives for each question were in a different order for each version. These are examples of pre-and posttest items from the tests for a video on flatworms:

> *Pretest:* These flatworms live in the bladder and lungs of animals: (a) Amphibians (b) Embryos (c) Flukes.

> *Posttest:* One of the surviving branches of flatworms is called: (a) Cestoda (b) Jellyfish (c) Snakes.

These are examples of pre- and posttest items from the tests for a video on algae:

> *Pretest*: What do the different types of algae have in common? (a) Prokaryotic cells and silica (b) Eukaryotic cells and plastids (c) Oblong shape.

> *Posttest:* One example of an oblong diatom is: (a) Pinnate (b) Tadpoles (c) Centric.

The posttests for the algae and flatworm videos are in Appendix A. Interitem reliability results (coefficient alpha) with the participant sample were .05 and .14 for the algae pre- and posttests, respectively. Test means were 4.54 (SD = 1.53) and 6.09 (SD = 1.60), respectively. Interitem reliability was .63 and .67 for the flatworm pre- and posttests, respectively. Means were 4.81 (SD = 2.36) and 6.77 (SD = 2.30), respectively.

Screen-capture recordings were made with the Camtasia software application (TechSmith, Inc.), which was installed on the desktop computer the students used for the present study. The application started simultaneously with the playback of a video, recording the entire screen and all student interactions with the video's contents. After students finished viewing a video, the researcher conducting the session would save the Camtasia recording for data analysis. The recordings showed which expanded captions were accessed, as well as other interactions with the DVD (e.g., pause, fast-forward, and back-forward). This information documented whether students used the expanded captions, and the frequency of their use.

A researcher conducted open-ended interviews to obtain participants' preferences and experiences with expanded and standard captions, as well as suggestions for improving the captions. Students responded to the following questions:

- How much experience have you had using captions to learn from educational videos?
- What do you like best about having captions available to you on educational videos?
- In this study, we provided a different type of caption: captions that allowed you to click on some of the words to get more information. Was this type of caption helpful to you? If yes, why? If no, why not?
- If you had your choice of captions, would you like: the standard captions, the ones you are used to having; or the new captions, the ones where you can click on words to get more information? Explain why.
- If you were designing captions for students who are deaf or hard of hearing, what would they look like and what would they be able to do?

The researcher administering the interview video audio-recorded the students' signed and/or spoken responses. Soon after interviewing each student, she transcribed these responses. Once all interviews had been transcribed, she and another researcher read the transcripts and developed a set of coding categories. Interview comments were then assigned to categories, and re-read to identify major themes that were supported through quotations from participants (Bogdan & Biklen, 2007).

Procedures

A researcher administered the procedures to one student at a time in single sessions of approximately 1.5 hours each. Each session had four parts: (a) training, (b) experimental video 1, (c) experimental video 2, and (d) an exit interview. The researcher who administered these procedures, a teacher of the deaf, used sign communication with or without voice, depending on the participant's preference.

Training

The training consisted of five steps. First, the researcher provided background information about the study and its purpose. Second, she explained the standard captions and demonstrated their use, and students then practiced using these captions for a few minutes with the standard-captions version of the video from the *Branches of Life* series on the Cnidarians, a phylum of invertebrates such as jellyfish. Third, she explained the expanded captions and demonstrated their use. This demonstration included instruction in using each of the three types of expanded captions. Students practiced using the expanded captions with the expanded-captions version of the Cnidarians video for approximately 5 minutes. Fourth, students completed five questions on a paper copy of the posttest for the Cnidarians video. Students were told (a) that this was a practice test, so that they would be familiar with the tests they would take on the other videos, and (b) that it was not a timed test. Fifth, students could ask questions about the two experimental conditions or the procedures.

Experimental Videos

Students viewed one video with standard captions in one content area and a second video with expanded captions in a second content area. Students were randomly assigned to one of four counterbalanced video content/treatment combinations:

1. the algae video with standard captions followed by the flatworms video with expanded captions
2. the algae video with expanded captions followed by the flatworms video with standard captions
3. the flatworms video with standard captions followed by the algae video with expanded captions
4. the flatworms video with expanded captions followed by the algae video with standard captions

This counterbalancing of video content/treatment combinations controlled for confounding of treatment with video content (and associated tests) and order. So that we could control for video content, half of the participants viewed one of the videos with expanded captions, and half of the participants viewed the same video with standard captions. The first half of the participants viewed the second video with standard captions, and the other half viewed the second video with expanded captions. Order was controlled for by having half of the participants view a video with expanded captions first, and the other half view a video with expanded captions second. The first half of the participants viewed a video with standard captions second, and the other half viewed a video with standard captions first.

For the first experimental video, students completed the pretest on the vocabulary and informational content; next, they watched the assigned video, then they completed the posttest. For example, students in video content/treatment combination (a) completed the pretest for the algae video, watched the algae video with standard captions, then completed the posttest for the algae video. The procedure for the second experimental video was similar to that for the first. For example, students in video content/treatment combination (a) completed the flatworms pretest, watched the flatworms video with expanded captions, then completed the flatworms posttest. During the viewing of experimental videos with expanded captions, Camtasia was used to capture a screen-based video of each student's experience with these captions. After completion of both experimental videos, students responded to the brief student exit survey, speaking and/or signing their answers.

Results

Performance on Content Tests as a Function of Captions and Test

The first set of analyses addressed the questions of (a) whether students performed better on a posttest after viewing the captions than on a pretest; and (b) whether students showed a greater gain in their score from pretest to posttest score in the expanded-caption condition than in the standard-caption condition. These analyses examined effects of two factors on performance on the content knowledge test: (a) captions (two levels: standard and expanded, a within-subjects factor) and (b) test (two levels: pre- and posttest, also a within-subjects factor). Table 2 presents the mean pre- and posttest scores for standard and expanded captions. A repeated-measures ANOVA was performed on the dependent variable of number of items correct on a test. The partial eta squared statistic (η_p^2) is reported for each main or interaction effect to provide an estimate of the effect size. This statistic indicates the amount of variance in the dependent variable(s) attributable to the particular effect of interest (Heiman, 2000).

The analyses revealed that there was a significant effect for test, $F(1, 21)$

Table 2
Mean Pre- and Posttest Scores for Standard and Expanded Captions

	Pretest			*Posttest*		
Captions	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Standard	4.27	1.75	2–7	6.36	1.86	2–10
Expanded	5.09	2.14	2–10	6.50	2.15	2–9

$= 31.18$, $p < .001$, $\eta_p^2 = .60$. This result indicated that the mean score for the posttests ($M = 6.43$, $SD = 2.01$) was higher than that for the pretests ($M = 4.68$, $SD = 1.94$).

There was not a statistically significant effect for captions, $F(1, 21) = 1.35$, $p > .20$, $\eta_p^2 = .06$ (standard captions, $M = 5.31$, $SD = 1.81$; expanded captions, $M = 5.79$, $SD = 2.14$). The Captions x Test interaction effect also was not statistically significant, $F(1, 21) = 1.22$, $p > .20$, $\eta_p^2 = .06$. This lack of an interaction effect indicated that there was not a significant difference between the pre-to-posttest improvement under expanded captions and under standard ones.

One additional analysis examined each student's change in score from pretest to posttest. For standard captions, 16 of the 22 students increased their score, with 14 of these 16 increasing their score by 2 or more points; 4 students decreased their score, all by 1 point, and 2 did not change their score. For expanded captions, 15 of 22 increased their score, 12 by 2 or more points; 5 decreased their score, 3 by 2 or more points; and 3 did not change their score. Thus, there was a strong tendency toward improvement of scores.

Because the reliabilities of the algae video pre- and posttests were low, a second additional analysis was conducted to determine whether these differences in scale reliability related to results for each set of tests. This analysis separately examined for the algae and the flatworm pair of tests the effects of captions (two levels; standard and expanded, a between-subjects factor) and test (two levels: pre- and posttest, a within-subjects factor). Results for each of these pairs of tests were virtually identical. For both the algae and flatworm pairs, scores were higher on the posttest than on the pretest, with each difference statistically significant at $p < .001$. Furthermore, for each pair of tests there was not a statistically significant difference between means for the standard and expanded-caption conditions, and there was not a significant Captions x Test interaction effect, with $p > .20$ for each of these tests. These results were also virtually identical to those for the initial analysis that used both the algae and flatworm pairs of tests.

Extent of Student Access to Expanded Captions

The video recordings of students' interactions with the computer produced with the Camtasia software while viewing the flatworms and algae instructional videos with expanded captions were analyzed to determine (a) the extent to which students accessed the expanded captions and (b) whether the extent that students accessed these captions changed from the first to second halves. This analysis computed the amount, by percentage, that students accessed expanded captions for the first half of the video, for the second half, and for the whole video. (As noted, viewing of the videos with standard and expanded captions was counterbalanced across participants; therefore, each participant viewed one of the two expanded caption videos.) Table 3 presents the mean percentage of expanded captions that students accessed for each half and for the entire instructional video.

As shown in Table 3, students accessed only some of the additional information in expanded captions, less than 20% on average. Furthermore, for both videos, students accessed more additional information while watching the first halves of these videos than while watching the second halves. Paired t tests that compared the mean percentage of expanded captions that students accessed for the two halves indicated that for the flatworms video, students accessed significantly more expanded captions in the first half than in the second, $t(11) = 8.42$, $p < .0001$; for the algae video, the difference was not statistically significant.

Exit Interviews

Students commented on the importance of captions in educational videos, indicated their preference for either standard or expanded captions, and suggested improvements in the design of captions. Students felt that captions on educational videos helped them understand what was happening and what was being said. Every participant who was interviewed made a positive comment about the benefits of captions. Some participants commented that captions were essential for understanding educational videos. One student said, "Without closed captions, I wouldn't understand anything that is happening."

Most students commented that seeing the spelling of complex terms in the captions helped them remember the terms. Several felt that captions were more helpful than interpreters for understanding educational videos.

Most students said they preferred the expanded captions to the standard ones. Students preferred these captions because when they clicked on a

Table 3
Mean Percentage of Expanded Captions Students Accessed for Each Half and for the Whole Instructional Video

Video and part	*n*	*M*	*SD*	*Range*
Flatworm				
Part 1	12	.24	.12	.08–.45
Part 2		.09	.12	.00–.36
Total		.16	.12	.04–.39
Algae	10			
Part 1		.17	.09	.08–.36
Part 2		.10	.11	.00–.36
Total		.13	.07	.04–.26

highlighted word in these captions, a window opened that immediately provided a definition of the captioned word in print, diagram, or picture format. This feature meant that students obtained an immediate explanation of the word; they did not need to write down the unknown word and then wait until they had access to a dictionary to learn the definition. As one student put it,

> The closed captions, with the extra titles and vocabulary, really helped me more. Because when watching in class with the standard captions I have to take notes on the words I don't know and I have to go home and study and make sure I understand.

In addition, students commented positively on the expanded captions' inclusion of pictures and diagrams because these materials supported visual learning and because the highlighting of captioned words signaled that a particular word was an important one to learn. Also, some students stated that they benefited from the opportunity to stop the video and view the expanded caption because doing this process required taking more time to process the information than if they did not have this opportunity.

Seven of the 22 students did not view the expanded captions as helpful. Reasons for preferring the standard captions were that accessing and viewing expanded captions interrupted the flow of information and consequently disrupted learning; processing the additional information in the expanded captions required too much time; the information in the expanded captions was already familiar to most viewers and was therefore unnecessary; and standard captions were more comfortable to use because they were more familiar. In regard to this last point, one student stated, "I would take the old-fashioned one because I am 27 years old and I know a lot. So at this point, if I needed to look something up I would just go on the Internet anyway."

In providing ideas for designing better captions, a number of students made suggestions for forms of captioning that were similar to the expanded captions in the present study. That is, videos would highlight captions for key words and students would be able to access definitions, pictures, and diagrams for these words. Students also suggested different ideas for better captions, grouped here into four categories. First, some students suggested that videos include more highlighted, expandable captions. Second, students suggested modifications in the pace of presentation of the captions and pictorial information in videos. One suggestion was to increase the spacing between highlighted words in the captions because when one highlighted word was immediately followed by a second one, the short interval between the two words sometimes resulted in students being unprepared to access the second highlighted word. Another idea was to modify the pace of presentation of the pictorial information and the captioning because students sometimes had difficulty simultaneously attending to and comprehending both parts of the video.

A third set of ideas involved changing the display so that students could more effectively relate the information in the segment with the original material in one window to the additional information that was in a different window. One suggestion was for the video to display the original information in a single window, with the highlighted caption in the background, when showing the additional information, rather than have the original video and caption and the additional information in two separate windows. A fourth set of ideas concerned providing more extensive information in the expanded captions. Expanded captions could include more charts, illustrations, examples, diagrams, signs, symbols, and pictures of the item being defined.

Discussion

The present study examined the effects of standard and expanded captions on deaf college students' comprehension of educational videos with biology content. The study found that students performed better, at a statistically significant level, on the posttest of comprehension than on the pretest for both the standard and expanded captions. However, results that compared pre-to-posttest gains in performance revealed that the extent of improvement under expanded captions was not different, at a level of statistical significance, from that under standard captions. Contrary to expectations, students did not appear to comprehend more of the video content when they had the opportunity to access vocabulary definitions, labeled illustrations, or concept maps while watching the separate window with the expanded captions.

Use of Camtasia recording software made it possible to examine the extent to which students accessed expanded captions. It is disappointing that students accessed the additional information in few expanded captions, less than 20% of the available captions, and the proportion that they accessed declined noticeably from the first half of the video to the second half. In spite of quite limited use of the expanded captions, students stated that they considered these captions beneficial in the interview that followed the videos and tests. Most students stated that they preferred expanded captions to standard ones, with the main reason being that the definitions of the highlighted words, which they often did not know, were immediately accessible in the expanded captions.

The discrepancy found in the present study between the students' perception of the expanded captions as helpful and their apparent failure to learn more with these captions may not be all that unusual in comparisons of student perceptions of an accommodation and their actual learning. For example, in one study (Elliot, Stinson, McKee, Everhart, & Francis, 2001), deaf college students self-reported that a real-time display of captions was beneficial, but in a second study, which included an experimental assessment of retention of lecture information (Stinson, Elliot, Kelly, & Liu, 2009), deaf college students did not retain more information with captions than with traditional (i.e., interpreting) services.

The preference for expanded captions may have been related to affective factors, such as students believing that these captions were helpful. Affective factors are important because they are associated with comprehension in reading and other academic activities (Taboada, Tonks, Wigfield, & Guthrie, 2009). This affective factor is a reason why it may be desirable to include expanded captions in educational videos. If students receive an accommodation they perceive as helping them perform better on a task, this may increase motivation and improve comprehension (Feldman, Kim, & Elliot, 2011).

Except for the finding of overall improvement in performance from pretest to posttest (i.e., for both standard and expanded captions), the results of the present study, with deaf college students, were generally similar to those of the Anderson-Inman et al. (2009) study, with deaf middle and high school students. Whereas the college students did significantly better on the posttest than on the pretest, the middle and high school students did not do significantly better on the posttest. The overall pre-to-posttest mean gain (1.75) was larger for the present study with college students than it was for the study with middle and high school students (0.96); the sample size for the college study was also larger (22 vs. 9). Both factors likely contributed to this difference between the results for these two studies.

One explanation for the greater improvement by the college students is that they were more proficient readers and users of English and had more academic studying and test-taking experience than the younger students. This interpretation is supported by previous research that found that more proficient readers are better at comprehending captioned videos (Burnham et al., 2008; Lewis & Jackson, 2001). The higher proficiency and greater experience of the college students may have been particularly important to their comprehension of the captioned materials because these materials seemed to be fairly difficult, based on relatively low mean posttest scores. The inclusion of numerous scientific terms that students needed to learn and the technical nature of the materials contributed to their difficulty level (Anderson-Inman et al., 2009).

In the present study and Anderson-Inman et al. (2009), pre-to-posttest gains in performance with the expanded and standard captions were not different from each other at a statistically significant level. In fact, there was a greater gain for the standard captions than for the expanded ones. (The difference was not statistically significant; it is possible, however, that if the sample size had been several times larger, the difference would have been statistically significant.) Also, in both studies, the participants accessed a relatively small percentage of the expanded captions, with the proportion of captions they accessed declining from the first to the second part of the video. The limited access to expanded captions provides an explanation of why participants did not benefit from them: Participants did not access enough of these captions. Students will not learn the scientific terms in the expanded captions if they do not access them.

Students may have been unaware that they did not know terms that they could have accessed, limited by features of the technology (e.g., length of time that words were highlighted), tired of accessing the captions, and/or desirous of hurrying through the experimental session. The suggestion that deaf students thought they knew highlighted terms in the expanded captions, and were unaware that they did not really know these terms, is consistent with research on metacognition of deaf students that indicates that these students often fail to use metacognitive strategies, such as being aware of what one does not know (Hauser, Lukomski, & Hillman, 2008; Marschark, Sapere, Convertino, & Seewagen, 2005).

In addition, usable hearing may have reduced the extent to which some students accessed the expanded captions. There were several students with mild hearing loss and/or a cochlear implant who may not have needed the captions to understand the video, or, alternately, used the captions to supplement the audio. These students may have infrequently accessed the expanded captions because these segments had no sound and the students may have preferred to hear the audio when watching the video. It is not clear, however, to what extent these students were able to benefit from the sound because the standard videos did not show the speaker's face, so the students could not use speechreading to help them understand the audio.

Certain features of the video technology may have limited the extent to which students could access and learn from the expanded captions. Students' comments in the interviews suggested that these features may have included a pace of presentation of the pictorial and captioned information that was too fast for them to process the information, consider whether they knew the highlighted word, then access it in a separate window. In addition, short time periods between highlighted words in the video may have resulted in students not being ready to access the additional information for a subsequent highlighted word if they had accessed the information for the previous highlighted word. Students also may have had difficulty relating the additional information that was in one window to the original video with the highlighted caption in the other window. At least some of these difficulties may have been due to students' lack of practice with using the expanded captions. Although students did receive training in using the expanded captions and did practice using them for several minutes prior to viewing them in the experimental session, it is likely that they would have become more proficient if they had had more practice with them.

In addition, students may have accessed the additional information in only a few expanded captions because there was insufficient incentive for them to carefully study the material. Since participants were volunteers and performance in the experiment was not tied to any course, the only incentive for the students to do well was a desire to do so for its own sake.

Generalization of the present study's findings to other deaf students is limited by the small sample size of 22 participants, the participants' relatively high level of reading proficiency, and their hearing levels. As noted, it is possible that a substantially larger sample might have demonstrated a statistically significant difference between gains in test performance in favor of standard captions. The participants' reading proficiency was substantially higher than that of the typical deaf high school graduate (Walter, 2010). This study's participants were probably more similar to other deaf students who attend 4-year postsecondary programs, who are presumably more proficient readers, than to students who attend 2-year programs or who are in secondary school programs. With respect to hearing level, 7 participants had hearing levels in the better ear in the mild to severe range, and 4 used a cochlear implant. Participants with different hearing levels might have accessed the videos and performed on the tests differently than this study's participants.

A limitation of the present study was the low reliability of the algae video pre- and posttests. It is not clear how this low test reliability affected the results. In the analyses for effects of test and captions that were conducted separately with the algae and flatworm sets of tests, test reliability did not appear to be related to results of the tests of statistical significance. It is possible that the difference in reliability related to variability in test performance. The average standard deviation for the flatworm tests was .77 larger than that for the algae tests.

Because the reliability of the algae pre- and posttests was low, the present study should be replicated with more reliable measures. Factors that may have contributed to the low reliability of the algae tests include unfamiliarity of the content, difficulty of items, limitations in students' proficiency in reading English, and use of an out-of-class experiment in which some students devoted limited attention to questionnaire items (McCrae, Kurtz, Yamagata, & Terracciano, 2011). It is also desirable for future research to be conducted as part of actual classes because researchers perhaps would better prepare the students to complete the tests and use the videos, and students might pay greater attention to these materials.

Recommendations for Future Research

Since neither the present study with college students or the Anderson-Inman et al. (2009) study with middle and high school student has shown that expanded captions increase comprehension, when the same set of materials and similar procedures are used, it is clear that future work on expanded captions needs to include modification of the materials and procedures. One modification would be to make more explicit to the students what they do and do not know in the material they are learning. For example, students could be given a study guide with questions about the content that they were responsible for learning in the video. This suggestion is based on research that interspersing questions throughout the text substantially increases students' learning of educational media content (Dowaliby & Lang, 1999; Lang & Steely, 2003).

In conclusion, although the expanded caption technology has yet to demonstrate its efficacy, it still seems promising because it addresses two key challenges deaf students often face in learning: First, the opportunity for more thorough review of material can help deaf students deal with language processing issues that these students often face; second, the opportunity for students to obtain definitions, illustrations, concepts maps, or other information can help them overcome challenges that result from limited content knowledge (Marschark, Convertino, McEvoy, & Masteller, 2004; Marschark et al., 2005). Given this potential, it is important for future research to find ways of using the DVD freeze-frame capability included in the present study that have a demonstrable impact on the learning of deaf students (Anderson-Inman et al., 2009).

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References

American College Testing. (2011). *2001 ACT national and state scores*. Retrieved from http://www.act.org/news/data/01/t4.html

Anderson-Inman, L. (2009). Supported eText: Literacy scaffolding for students with disabilities. *Journal of Special Education Technology, 24*(3), 1–7.

Anderson-Inman, L., & Horney, M. A. (2007). Supported eText: Assistive technology through text transformations. *Reading Research Quarterly, 42*, 153–160.

Anderson–Inman, L., Terrazas-Arellanes, F., & Slabin, U. (2009). Supported eText in captioned videos: A comparison of expanded versus standard captions on student comprehension of educational content. *Journal of Special Education Technology, 24*(3), 21–34.

Baker, R. (1985). Subtitling television for deaf children. *Media in Education Research Series, 3,* 1–46.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theories and methods* (5th ed.). New York, NY: Pearson Education.

Braverman, B. B., & Hertzog, M. (1980). The effects of caption rate and language level on comprehension of a captioned video presentation. *American Annals of the Deaf, 125*(7), 943–948.

Burnham, D., Leigh, G., Noble, W., Jones, C., Tyler, M., Grebennikov, L., et al. (2008). Parameters in television captioning for deaf and hard-of-hearing adults: Effects of caption rate versus text reduction on comprehension. *Journal of Deaf Studies and Deaf Education, 13*(3), 391–404. doi:10.1093/deafed/enn003

Dowaliby, F. J., & Lang, H. G. (1999). Adjunct aids in instructional prose: A multimedia study with deaf college students. *Journal of Deaf Studies and Deaf Education, 4*(4), 270–282.

Elliot, L., Stinson, M., McKee, B., Everhart, V., & Francis, P. (2001). College students' perceptions of the C-Print speech-to-text transcription system. *Journal of Deaf Studies and Deaf Education*, *6*(4), 285–298.

Feldman, E., Kim, J. S., & Elliott, S. N. (2011). The effects of accommodations on adolescents' self-efficacy and test performance. *Journal of Special Education*, *45*(2), 77–88.

Fels, D. (2002, July). *Issues of closed captioning and interactive television*. Paper presented at the meeting of the International Conference on Computers Helping People With Special Needs, Linz, Austria.

Hauser, P., Lukomski, P., & Hillman, T. (2008). Development of deaf and hard-of-hearing students' executive function. In M. Marschark & P. Hauser (Eds.), *Deaf cognition: Foundations and outcomes* (pp. 286–308). New York, NY: Oxford University Press.

Heiman, G. W. (2000). *Basic statistics for the behavioral sciences*. Boston, MA: Houghton Mifflin.

Lang, H. G., & Steely, D. (2003). Web-based science education: What research says to the teacher. *Instructional Science, 31,* 277–298.

Lewis, M. S. J., & Jackson, D. W. (2001). Television literacy: Comprehension of program content using closed captions for the deaf. *Journal of Deaf Studies and Deaf Education, 6*(1), 43–53.

Marschark, M., Convertino, C., McEvoy, C., & Masteller, A. (2004). Organization and use of the mental lexicon by deaf and hearing individuals. *American Annals of the Deaf, 149*(1), 51–61.

Marschark, M., Sapere, P., Convertino, C., & Seewagen, R. (2005). Access to postsecondary education through sign language interpreting. *Journal of Deaf Studies and Deaf Education, 10*(1), 38–50.

McCrae, R. R., Kurtz, J. E., Yamagata, S., & Terracciano, A. (2011). Internal consistency, retest reliability, and their implications for personality scale validity. *Personality and Social Psychology Review, 15*(1), 28–50.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. New York, NY: Houghton Mifflin.

Silverman, C., & Fels, D. (2002, July). *Emotive captioning in a digital world*. Paper presented at the meeting of the International Conference on Computers Helping People With Special Needs, Linz, Austria.

Stinson, M. S., Elliot, L., Kelly, R. R., & Liu, Y. (2009). Deaf and hard of hearing students' memory of lectures with speech-to-text and interpreting/note-taking services. *Journal of Special Education*. *43*(1), 52–64.

Taboada, A., Tonks, S. M., Wigfield, A., & Guthrie J. T. (2009). Effects of motivational and cognitive variables on reading comprehension. *Reading and Writing, 22*, 85–106.

Treviranus, J. (2000). *Click the caption, select the descriptions: Making captioning and video description essential for any learning in broad-band education.* Toronto, Canada: Adaptive Technology Resource Centre, University of Toronto.

Wagner, M., Newman, L., Cameto, R., & Levine, P. (2006). *The academic achievement and functional performance of youth with disabilities: A report from the National Longitudinal Transition Study–2* (NCSER Report No. 2006-3000). Menlo Park, CA: SRI International.

Walter, G. G. (2010). *Deaf and hard-of-hearing students in transition: Demographics with an emphasis on STEM education*. Retrieved from website of the National Technical Institute for the Deaf, Rochester Institute of Technology: http://www.rit.edu/ntid/cat/sites/default/files/Transition%20demographic%20report%206-1-10.pdf

Ward, P., Wang, Y., Paul, P., & Loeterman, M. (2007). Near-verbatim captioning versus edited captioning for students who are deaf or hard of hearing: A preliminary investigation of effects on comprehension. *American Annals of the Deaf, 152*(1), 20–28.

Woodcock, R. W., McGrew, K. S., and Mather, N. (2001). *Woodcock-Johnson Tests of Academic Achievement—research edition*. Itasca, IL: Riverside.

Appendix A

Posttests for the Algae and Flatworm Videos

Algae

Directions: Circle the letter next to the correct response.

1. Select the one that is an example of golden-brown algae.
   a) Euglena
   b) Shellfish
   c) Sea palms
2. One example of an oblong diatom is:
   a) Pinnate
   b) Tadpoles

c) Centric

3. These female sex cells will produce Spirogyra algae.
   a) Zygotes
   b) Plankton
   c) Sperm
4. Diatoms extract this crystal from surrounding water.
   a) Pigments
   b) Salt
   c) Silica
5. Algae make and store food in their:
   a) Stomach
   b) Plastids
   c) Nuclei
6. Which single-cell algae can be seen floating in water?
   a) Diatoms
   b) Plants
   c) Dinoflagellates
7. Euglenids are a type of ____________ found in water.
   a) Compound
   b) Red algae
   c) Green algae
8. What do the different types of algae have in common?
   a) Eukaryotic cells and plastids
   b) Oblong shape
   c) Prokaryotic cells and silica
9. The small animal that feeds on dinoflagellates (making it dangerous to humans) is called:
   a) Larvae
   b) Mollusk
   c) Ant
10. These organisms are not plants or bacteria.
   a) Roses
   b) Algae
   c) Streptococci

Flatworms

Directions: Circle the letter next to the correct response.

1. These flatworms live in the bladder and lungs of animals.
   a) Amphibians
   b) Embryos
   c) Flukes
2. One of the surviving branches of flatworms is called:
   a) Cestoda
   b) Jellyfish
   c) Snakes
3. Human beings function as hosts for a flatworm called:
   a) Flukes
   b) Earthworm
   c) Taenia solium
4. What happens when human beings eat tapeworm eggs?
   a) The eggs are digested.
   b) The eggs are regurgitated.
   c) The eggs turn into worms that kill.
5. What do large flatworms eat?
   a) Algae
   b) Insects
   c) Crustaceans
6. On what surfaces do ectoparasites live?
   a) Rocks
   b) Water
   c) Fish and amphibians
7. Flatworms are organisms that have the following form.
   a) Triangular
   b) Bilaterally symmetrical
   c) Radially symmetrical
8. These flatworms are able to avoid bright sunlight.
   a) Planarian
   b) Monogenea
   c) Tapeworm
9. The segments of a tapeworm that have both male and female sex organs are called:
   a) Mammalia
   b) Proglottids
   c) Scolex
10. Larvae that live on snail tissue develop into sacs called:
    a) Tendon cells
    b) G cells
    c) Germinal cells