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ABSTRACT

This study evaluated the use of children's literature presented via one of three conditions: an adult reading a book to the child; the child reading a CD-ROM version of a book on the computer but without animation; and the child reading the book on the computer with high levels of animation. The study, in one primary grade classroom, involved 10 students with learning disabilities and 10 students without disabilities. Students preferred the high animation computer condition, spending almost four times as much time "reading" the book in this condition than the adult reader condition. However, students obtained the highest scores on comprehension questions in the adult-reader condition. The high animation condition appeared to mislead students into drawing wrong conclusions about the text. Students in the low-animation condition did not tend to make use of such features as clicking on words to hear them pronounced and requesting that pages be re-read. There were no statistical differences between students with and without learning disabilities on any dependent measures. (Contains 17 references.) (DB)

The Impact of Animation in CD-ROM Books on Students' Reading Behaviors and Comprehension

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Introduction

Multimedia technology, which facilitates the development of educational materials that combine text with images, sounds, and motion video, offers many potential benefits that may improve learning. Children can now listen to a variety of popular children's books at the computer. Digitized speech permits these books to be read by a variety of different voices, ranging from child-like to adult, which are as enticing and enthusiastic as the most well-versed storyteller. As the book is "read," individual words are highlighted, drawing the child's attention to the link between speech and print. Important literacy skills develop through repeated exposure to storybook reading, including an understanding of the purpose of reading; knowledge of print conventions, vocabulary and story schemas; and an interest in reading.

The use of digitized speech to "read" books to children who would otherwise be unable to decipher print may be especially important for poor readers. These students can now enjoy a wide variety of age-appropriate books that are above their reading level without having to depend on others. These reading experiences may enhance students' motivation to read and promote students' self-efficacy as readers. Motivational advantages may be especially important for students with learning disabilities, who are often denied the opportunity to enjoy and learn from text due to difficulties at the level of word recognition (Stanovich, 1991; Wise, 1991).

In addition to reading the text, multimedia books can provide students with nearly instantaneous assistance with features of the text. Features of multimedia books may improve students' literacy learning by providing procedural facilitation with basic word recognition and vocabulary skills. Digitized speech can be used to read or re-read words, phrases, sentences, and pages upon the user's request. More extended assistance can be provided in the form of definitions, syllabication, links between potentially ambiguous words and their referents, animated illustrations, and prompts to promote more sophisticated comprehension strategies.

Despite the potential benefits discussed above, students may fail to learn from multimedia books because they do not take full advantage of the learning opportunities embedded in these materials (Perkins, 1985; Salomon, Globerson, & Guterman, 1989). Students with learning problems or disabilities may be especially handicapped, as they may lack the metacognitive sophistication to know when they need help. Some researchers have found that poor readers and students with learning disabilities are less likely than their nondisabled peers to take advantage of computer-based assistance designed to promote comprehension, such as opportunities to reread or prompts to use comprehension strategies. Consequently, the poorer students do not perform as well on comprehension of the computer-presented text used in these studies (Keene & Davey, 1987; Reinking & Schriener, 1985; Swanson & Trahan, 1992).

Other features of multimedia books may have a detrimental effect on students' comprehension. Given the increasing storage capability available through CD-ROM technology, multimedia books can now contain extensive sequences of animation. Many studies have shown that static and dynamic illustrations that support or amplify accompanying text improve students' comprehension. However, not all illustrations are created equal. Illustrations and animation that do not support the text may not improve and may even hinder comprehension (Samuels, 1967). Some researchers have found that extraneous images may distract students, drawing their attention away from the main points of the text, much in the same way as seductive details embedded in the text distract the learners attention from more important ideas. Rose (1986) has demonstrated students with learning disabilities may be particularly distracted by illustrations. Furthermore, some studies have found that students invest less mental effort in activities that are perceived as entertaining, and thus learn less than they would from more traditional print-based materials (Salomon, 1983; 1984; Salomon & Leigh, 1984).

Despite the burgeoning interest in and development of multimedia books, there are very few studies examining how students use these materials and what they learn from them. In a qualitative study, Miller, Blackstock, and Miller (1994) observed four third-grade children who worked with CD-ROM storybooks over five sessions. These students read the same Discis book (the type of books used in the low-animation condition of our study), tailored to his or her interests and reading level, during each session of the study. The authors demonstrated that students requested assistance from the program with words they

could not read. By clicking on these words and hearing them pronounced, students learned many of the words they previously could not read. However, the authors did also found that students did not request assistance for all the words they could not read. Moreover, some students seemed less inclined to seek help from the program than others.

In this study, we sought to expand information available about the strategies students use when they "read" books available on CD-ROM and the effects of these books on students' comprehension. We compared students' reading behaviors and comprehension of text under three conditions: (a) adult reading a book to child (or Adult-Reader condition), (b) child reading a Discis Book at the computer (Low-Animation condition), and (c) child reading a Living Book at the computer (High-Animation condition). Discis and Living Books are CD-ROM versions of children's literature. Both contain text and illustrations from the original print versions and both "read" the text and individual words, upon request, with digitized speech.

The comparison of primary interest in this study was the degree of animation accompanying the story. A user can click on almost any aspect of the illustration in a Living Book and view clever and engaging animation sequences. In Discis books, when the user clicks on an element of the picture, a written label of that element is displayed, spoken, and sometimes accompanied by sound effects.

Based on a pilot study and research cited above, we predicted that the extensive and engaging animation of a Living Book would cause students to spend the most time in this condition. Moreover, we hypothesized that students would be more engaged with the text in the high animation condition. Moreover, we predicted that students would prefer the high animation Living Book. Despite these predicted outcomes, we thought that the high animation condition would have a deleterious effect on students' comprehension. In fact, we hypothesized that comprehension would be best when there was no computer-based animation, as in the case of a story read by an adult. We hypothesized that the high animation condition would be especially detrimental to students with learning disabilities (LD). Also, because students with LD often have difficulty monitoring their understanding of text, we thought that LD students would also be less likely to request that pages and words be reread to facilitate comprehension.

Method

Sample. Twenty students participated in this study. Nineteen were from the same classroom in a northern Delaware school. The classroom employed a Team Approach to Mastery (TAM) model, in which students with mild disabilities and those without are team-taught by a regular and special educator, who are assisted by a paraprofessional. The ratio of students with and without disabilities in this class was 1 to 3.

All 10 learning disabled students in the class were invited to participate. Ten students without disabilities, who were judged by the teachers to be average readers for this class, also were asked to participate. When one student with a learning disability did not return a permission form, we asked a second grader from a laboratory school for children with learning disabilities to participate.

Delaware's definition of learning disability is consistent with the federal definition and diagnosis is based on a severe discrepancy between ability and achievement in one of eight educational areas (e.g., basic skill reading, reading comprehension, written expression). A severe discrepancy is determined by reference to a formula that takes into account the correlation between specific IQ and achievement measures used in the diagnosis. The discrepancy formula is designed to permit a 5% prevalence rate of learning disabilities in the school population (Delaware Department of Public Instruction, 1987).

The average age of the sample was 7.98 years (SD = .5). Seventy percent (n = 14) of the sample was male. Sixty-five percent were Caucasian (n = 13), 25% were African-American (n = 5), 5% were Hispanic (n = 1), and 5% were Asian (n = 1).

Eighteen of the twenty students had taken the California Test of Basic Skills seven months prior to the study. Reading scores were available as percentile ranks. Total reading scores were 19.9 (SD = 11.29) for the students without disabilities and 5.13 (SD = 6.03) for students with disabilities. T-tests show that students with and without disabilities differ significantly in total reading score. However, the average

scores for students without disabilities did not exceed the 20th percentile, suggesting that they, too, should be considered poor readers.

All students had used a computer prior to this study. Two computers were located in their classroom, which were used on a regular basis for drill and practice, word processing, and games. Two CD-ROM books, similar to the one used in the high-animation condition, were available for students' use throughout the school day.

Materials. A different book was used in each condition. The classroom teachers helped us choose three titles that were available in a CD-ROM format, that were consistent with students' interest and general reading levels, and that students were unlikely to have read previously.

In the high-animation condition, students used "Harry and the Haunted House" (Schlichting, 1987). This book is one of the titles in Random House/Broderbund's, "Living Books" series. The book has 12 pages with 12 unique illustrations. As with other Living Books, each page of the book contains a few sentences of text followed by the same illustration contained in the original print version. When the student turns to the page with a click of the mouse, the text is "read" in high-quality digitized speech. The reading is often accompanied by a brief sequence of dialogue or animation that amplifies the text. The student then can click on an icon at the beginning of the text to hear it re-read. S/he can click on any word in the text to hear it again. And, the student can click on many different elements of the picture to see additional sequences of dialogue and animation. For example, on a page that shows Harry and his friends contemplating whether or not to enter the house, clicking on Harry causes him to pound on the door again. Clicking on a mouse hole causes a mouse to peek through the window and giggle at the characters' startled gasps. Clicking on a window curtain causes it to transform into the shape of a ghost and issue a spooky melody.

In the low-animation condition, students used "Thomas' Snowsuit" (Munsch, 1985). This book is a title in the DISCIS book series. The CD-ROM book has 21 pages with 10 unique illustrations, although the original book has 10 pages and 10 unique illustrations. Each page of the book contains a few sentences of text followed by an illustration. The same illustration is repeated on one or two subsequent pages, as in the original text. DISCIS books can be set to operate in several different ways and we thus set features to be as similar as possible to those available in the high animation condition. When students turned to a page, the text was first "read" by a high-quality digitized voice. After the reading, the student can click on an icon to hear any sentence re-read or s/he can click on any individual word and hear it again. In addition, the student can click on many elements of the picture. Clicking on an item or character elicits a written label that names that element (e.g., "Thomas," "underwear," or "coathook"), a voice that reads the label, and, on occasion, a sound effect associated with the label. For example, if the user clicks on the character Thomas, a box appears with Thomas' name inside and a voice says "Thomas."

In the adult-reader condition, students listened to us read "The Paper Bag Princess" (Munsch, 1980). The book has 12 pages with 12 unique illustrations.

Instruments. We used two different measures to assess students' text comprehension. First, we asked students to retell each story. We adapted directions and prompts for this procedure from Morrow (1985). Story retells were audiotaped and transcribed. Second, we developed eight comprehension questions about each story. Six of the questions were text-explicit, or could be answered directly from the text. Two questions were text-implicit and required students to make inferences that went beyond information contained in the text.

Because the same book was not available in both the high animation and low animation format, we used different books in each condition. Book is confounded with condition. Thus, we needed to rule out the possibilities that differences in the ease with which the books could be understood, rather than differences in the conditions, were responsible for differences in the comprehension measures. To do this, we selected a control sample of eight second-graders from a school with demographic characteristics comparable to the one in which the study was conducted. These eight students were similar to the study sample in reading achievement and none had a learning disability.

The first author worked individually with each child in the control sample in a quiet room or in a quiet

hallway. She read each of the three books to students, in a counterbalanced order, and then asked them to retell the stories and answer comprehension questions. For the stories used in the high animation, low animation, and adult-reader conditions, average scores on the comprehension questions for the control sample were 65.8% (SD = 15.7%), 65.0% (SD = 14.6%), and 63.5% (SD = 22.8%), respectively. Thus, the scores were nearly identical. Story retelling scores for the stories used in the high-animation, low-animation, and adult-reader conditions were 13.4% (SD = 4.9%), 21.2% (SD = 13.6%), and 14.9% (SD = 12.3%). Thus, story retelling data must be interpreted with caution, as these data suggest that the story used in the low animation condition may be easiest to retell.

Procedures. Each student participated in all three conditions of this study, in a counterbalanced order. Students participated in only one condition per day. In the high- and low-animation conditions, students used a CD-ROM book on a Macintosh Centris 650 computer with a color monitor. The computer was located in a room adjacent to the classroom or in the library. One of the authors sat behind the student, assisting him or her when necessary and recording information about his/her interactions with the CD-ROM on a printed version of the CD-ROM text. In the adult-reader condition, one of the authors read a book to the student in an adjacent room or in the quiet section of the hallway. We sat next to the student, letting him or her hold one copy of the book while we read from and recorded comments on another.

We introduced each condition to the student with a brief statement about the story itself. In the high- and low- animation conditions, we told the students that they would hear a story read by the computer and that, after the story, we would ask them some questions about it. We then loaded the CD and accessed the first page of the story. After listening to the first page, we showed the student how to access a picture element, word, and sentence. We clicked on each of these features and then asked the student to do the same. We told the student that s/he could click on as many of these features as they wished and asked them if they would like to see anything else on the first page. When students stated they were finished, we showed them how to move to the next page and then turned over the mouse to them.

If a student had not clicked on a picture, word, or sentence after the third page, we prompted them for each feature they had not used by saying "Remember, you can click on a word (picture, or sentence)." We pointed to each feature as we mentioned it in the prompt.

After introducing the story to the student in the adult-reader condition, we read the first page and then told the student, "you can ask me questions about the pictures on any page. Let's say that you wanted to what this is. (We pointed to a tennis racket.) You could ask me, 'what's this?' and I'd say 'that's a tennis racket'. Now, you ask me a question about the picture on this page." We repeated similar directions for a sentence and for a word, telling students we could re-read each of these elements for the student and then directing them to ask us to reread. We directed students to tell us when to turn the page and begin reading the next one. As in the animation conditions, we reminded students to ask us about pictures, sentences, and/or words if they had not done so after the third page.

After students finished each book, we asked them to retell the story. We prompted them with "anything else" until they indicated that they could remember nothing more. We then asked them the eight comprehension questions. Finally, we asked students to tell us what they liked about the book in each condition. After students heard all three books, we asked them to tell us which book they liked the best and why.

Data Analysis. We developed a scoring system to assess the completeness and accuracy of students' responses to comprehension questions and awarded 0, 1, or 2 points for each answer. We parsed each story and each students' story retell into story elements, following guidelines developed by Merritt and Liles (1987). We then scored each story retell for the number of elements it contained that corresponded to the original story. Comprehension question and story retell data are reported as percents, as the potential total score for each story varied slightly. We also counted the number of extra story elements included in each students' story retell.

Students' engagement with the text was measured by two clusters of variables: (a) interaction with the page as measured by the number of clicks of the mouse on words, sentences, and picture elements and (b) the number of spontaneous comments made by students. We categorized comments as text-related or

media-related comments. Text related comments included predictions about the text ("oh, I know what will happen next, they'll go in the house"), personal reactions to the story ("I wouldn't do that!"), questions or comments about vocabulary ("what does that word mean?") and reading along with digitized voice. Media-related comments included questions or comments about the animation or sound effects.

The first author coded all the data and the second author independently coded 25% of the data. Inter-rater agreement, as determined by dividing agreements by agreements + disagreements, ranged from 98% agreement for story elements to 87% for computer-related comments.

We computed separate 2 (disability--LD versus nondisabled) x 3 (condition--adult-reader, high animation, low animation) mixed ANOVAs to determine differences in: (a) time spent reading each book, (b) comprehension question scores, (c) story elements, (d) total interactions with the page, and (e) total comments.

Results

Students spent the least amount of time in the adult-reader condition ($\underline{M} = 5.90$, SD = 1.48). As predicted, they spent the most time in the high-animation condition ($\underline{M} = 24.8$, SD = 8.25), with the low-animation condition falling midway between ($\underline{M} = 15.15$, SD = 4.24). Neither the disability nor the disability x condition interaction were significant, but we obtained a significant effect for condition, $\underline{F}$ (2, 36) = 61.06, $\underline{p} < .000$. Follow-up tests showed that each condition was significantly different from all others.

In response to comprehension questions, students obtained an average score of 44.7% ($\underline{SD}$ = 14.8%) in the high animation condition, 56.0% ($\underline{SD}$ = 14.6%) in the low animation condition, and 69.6% ($\underline{SD}$ = 18.1%) in the adult-reader condition. The ANOVA showed no significant effect for disability or for the disability x condition interaction. We obtained a significant effect for condition, $\underline{F}$ (2, 36) = 31.68. Follow-up tests showed that each condition was significantly different from the others.

The story retell data follow a slightly different pattern. Students recalled 21.3% ($\underline{SD}$ = 12.3%) of the story elements in the low animation condition, 17.8% ($\underline{SD}$ = 11.5%) in the adult-reader condition, and 10.9% ($\underline{SD}$ = 5.2%) in the high animation condition. Once again, we found a significant effect only for condition, $\underline{F}$ (2,34) = 12.04, $\underline{p} < .000$. Follow up tests showed that the high animation condition was significantly different from the low animation condition and from the adult-reader condition. However, the low animation and adult-reader condition did not differ significantly from one another. We found no differences in the extra information students included in their story retells among conditions. Students added an average of 3.16 ($\underline{SD}$ = 3.04, median = 2), 2.90 ($\underline{SD}$ = 2.44, median = 3), and 3.11 ($\underline{SD}$ = 4.04, median = 2) extra story elements in the high animation, low animation, and adult-reader conditions, respectively.

Table 1 shows the number of times students interacted with information on the page. As discussed above, interactions were defined as a click of the mouse on a sentence, word, or picture element in the high and low animation condition and a question about a word, sentence, or picture in the adult reader condition. An ANOVA, conducted on total interactions, showed that neither the disability nor the disability x condition interaction were significant. We obtained a significant effect for book, $\underline{F}$ (2,36) = 25.56, $\underline{p} <$ .000. Follow up tests showed that each condition differed significantly from the others.

As shown in Table 1, the vast majority of interaction in the high and low animation conditions occurred when students accessed picture elements. Students accessed nearly twice as many picture elements in the high- than low-animation condition. Students rarely clicked on words or sentences in these conditions to request a re-reading. However, there were considerable individual differences in the frequency with which students used these features of the CD-ROM programs, as evidenced by the large standard deviations associated with these items.

In the adult-reader condition, students were most likely to ask us to reread an individual word and occasionally asked a question or made a comment about a picture element. However, these behaviors were infrequent and highly variable across students. For example, one student asked about 17 picture

elements, another asked about 44 words. However, most students asked about neither picture elements or words, and no one asked us to reread a sentence.

As discussed above, we recorded any spontaneous comments that students made as they read or listened to each story. The number of comments per condition are displayed in Table 2. Students made the most comments in the high- animation condition and the fewest comments in the adult-reader condition. An ANOVA on total comments showed a significant effect for condition, $F(2,36) = 6.33$, $p < .005$. Follow up tests showed that students made significantly more comments in the high animation condition than in the adult-reader condition. Neither disability nor the condition x disability interaction were significant.

The average number of comments in the media- and text-related categories is displayed in Table 2. Large standard deviations suggest that there was a great deal of variability in the frequency with which students talked. For example, while participating in the high-animation condition, one student made 42 comments. Other students made no comments. Data about the median number of comments in each condition suggest that students made about the same number of media-related and text-related comments while participating in the high-animation condition. In contrast, students were somewhat more likely to comment about the media in the low-animation condition. Not surprisingly, students were more likely to comment about the text in the adult-reader condition.

As discussed above, when students finished each condition they were asked whether or not they liked the story and what they liked most about it. Apparently, the students enjoyed each of the stories, as all 20 stated that they liked each book. After completing all three conditions, students were asked to choose the story they liked the best. Sixteen of the 20 students (80%) stated they liked the story in the high-animation condition best, 2 students (10%) preferred the low-animation story, 1 student (5%) preferred the adult-reader story, and 1 student (5%) stated that he liked all three stories equally well.

Discussion and Implications

This study produced several results that have important implications for educators interested in using multimedia technology in literacy instruction and for developers of CD-ROM books. We found that, although students enjoyed all three conditions, they liked the high animation condition the best. They spent almost four times as much time "reading" the book in this condition as they did listening to an adult read a story. They were more engaged with the book in the high animation condition, as evidenced by the greater number of comments and interactions with picture elements. Moreover, students' comments were somewhat more likely to focus on the text in the high animation condition, suggesting that they were thinking about the story as well as the animation.

However, more time and engagement did not produce greater comprehension. As predicted, students obtained the highest scores on comprehension questions in the adult-reader condition. The story retell data are more difficult to interpret, given that data in a control sample suggest that the story in the low animation condition was the easiest to retell. An examination of students' responses to comprehension questions revealed that the extensive animation sequences in the high animation condition often *misled* them and caused them to draw conclusions that were inconsistent with the text. The characters of the story used in this condition enter a house that they believe to be haunted to retrieve a lost baseball. As they search for the ball, they encounter sights and hear noises that could be attributed to ghosts, but that always have earthly causes (e.g., a dog scratching his fleas, a character's reflection in a mirror). At the conclusion of the story, the characters conclude that the scariest thing in the house was themselves. However, animation sequences show apparitions and inexplicable events. Almost all the students concluded that the house was haunted, they usually included details of the animation sequences in their story retells, and they often justified their answers to comprehension questions by referring to picture elements rather than to the text.

Contrary to our initial predictions, students with learning disabilities were not differentially affected in the high animation condition. In fact, there were no statistically significant differences between students with and without LD on any of our dependent measures. These findings need to be evaluated in the context of the sample, however. Most of our non-LD students were poor readers, and thus may be similar to students with learning disabilities in reading skills and strategies. We may have seen greater differences in a sample of average or good readers.

Although clicking on words to hear them pronounced and requesting that pages be reread could provide additional practice that improves word recognition skills and comprehension, students did not make extensive use of these features. These results suggest that educators must be cautious in their expectations about the contributions of CD-ROM books to literacy learning. Perhaps they are best viewed as an additional, albeit motivating, element of a comprehensive literacy curriculum. These books can provide students with additional practice opportunities with stories and vocabulary on which students will receive instruction. In order to make fuller use of the instructional features of CD-ROM books, teachers may need to offer much more instruction and guidance than we did in this study, in addition to monitoring student use and perhaps providing incentives for improved word recognition or comprehension.

Our results also show that there may be liabilities inherent in CD-ROM books, especially those that contain extensive animation that does not support the text. Software developers need to be familiarized with the body of literature supporting both the facilitative and deleterious impact that images can have on text comprehension (e.g., Bransford & Johnson, 1972; Cognition and Technology Group at Vanderbilt Learning and Technology Center, 1993; Kozma, 1991; Levin & Lesgold, 1978) and design software accordingly. In addition, our data suggest that educators should preview educational applications for the correspondence between images and text. Rather than eschewing programs which lack correspondence, teachers may wish to help educate students about ways to interpret animation and analyze its relationship to text. In this manner, teachers will assist students in becoming sophisticated consumers in an increasingly visual world.

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Table 1

Number of picture elements, sentences, and words accessed

	M	SD	Median
High Animation			
Picture elements	82.80	51.67	71.00
Words	5.15	9.76	0.00
Sentences	1.40	3.12	0.50
Total interactions	89.35	49.64	84.00
Low Animation			
Picture elements	45.65	42.06	39.00
Words	6.35	9.16	2.50
Sentences	3.15	8.22	1.00
Total interactions	55.15	46.74	41.50
Adult Reader			
Picture elements	2.30	4.46	0.00
Words	4.50	13.34	0.00
Sentences	0.00	0.00	0.00
Total interactions	6.80	13.54	1.00

Table 2

Text-related and media-related comments

	M	SD	Median
High-animation			
Total comments	8.05	10.23	6.00
Text-related	2.40	2.48	2.00
Media-Related	5.65	8.44	2.00
Low-animation			
Total comments	5.25	5.92	2.50
Text-related	1.60	2.11	0.50
Media-related	3.56	4.18	1.50
Adult-reader			
Total comments	2.35	3.86	1.00
Text-related	1.40	2.39	0.50
Media-related	.95	1.73	0.00