Content Understanding of Science Texts of Students with Learning Disabilities using Text to Speech and Embedded Support Features

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Government mandates require students with disabilities educated in separate facilities or self contained classroom to access and make progress towards grade level standards (Cawley, 2002). Due to the percentages of students with high incident disabilities educated inside of the general education setting, accessing the general education curriculum for their grade level, and taking state wide standards based assessments, providing supports for students with disabilities to access the curriciulum becomes essential. Because of poor reading skills, primary students diagnosed with learning disabilities often have difficulty accessing the text which accompanies grade level curriculum. Additionally, as students with learning disabilities begin to transition from elementary into middle school, the demands upon reading and comprehension becomes even greater, especially in core content areas of social studies and science.

Because of increasing difference between independent reading level and grade level content in addition to poor decoding skills, many students in upper elementary school may find content area text especially challenging to read, which directly effects student comprehension (Garjia, 2007). Students diagnosed with learning disabilities may also have difficulties within the areas of focus and motivation, which increase their difficulties in accessing and having success in grade level content. In addition, science concepts in school textbooks are often inappropriate and do not match what the student can learn and his or her grade level (Sadler, 1997). Because of the student’s challenges, the requirement of accessing grade level curriculum, and the difficulty of grade level text, students in special education accessing grade level curriculum require the needed supports to access and succeed within the curriculum.

**Literature Review**

Regardless of the student’s disabilities, assistive technology paired with specific strategies has the potential to bridge the gap between a student’s independent reading level and their grade level content. Previous research has determined that audio text can positively impact student comprehension (Dolan, 2005; Mooram, 2010, Dawson, 2000). In addition, studies have also determined the efficacy of graphic organizers as a specific strategy that can increase comprehension on a variety of text (Solis, 2012). Text to speech (TTS) features allow students to listen to text aurally while looking at the printed text, which may adjust for decoding difficulties and could possible increase compression. Graphic organizers, as a separate strategy, help students with learning disabilities organize information in a visual format, to increase the understanding of information by understanding their connection. Although both TTS and graphic organizers can support comprehension, very little research has combined graphic organizers and TTS features as a combined strategy in supporting the comprehension needs of upper elementary students in accessing grade level curriculum. However, many studies have determine the efficacy of text to speech features on comprehension of students with learning disabilities in the areas of assessment as well as classroom content (Dolan, 2005; Mooram 2010; Boyle, 2002; Douglas, 2011). Therefore, the current study will evaluate the effects of reading digital text with dynamic highlighting and reading digital texts with the support of digital graphic organizers on the expository comprehension of students diagnosed with learning disabilities in science content area. The following sections will review the supporting literature in the areas of TTS and assessment, TTS and reading comprehension, graphic organizers, and issues with science comprehension measures.

**TTS support for students with disabilities in assessment**. TTS has been used as an accommodation for students with learning disabilities during assessments. The results for the studies have indicated that TTS has a positive impact on student comprehension. Dolan and Banjaree (2005) supported the effectivness of text to speech in increasing the comprehension of students with learning disabilities during assessment. The experimental study compared the effects of TTS accommodation while reading digital text on a computer on high school students with learning disabilities to reading and taking the test with traditional paper and pencil. Data from the study demonstrated a comprehension increase with the treatment group that received the assessment on the computer with the read TTS treatment in comparison to students who completed the test without the audio support. An additional study, conducted by Dolan and Banerjee (2005) also found an increase in student comprehension when students utilized TTS while reading comprehension passages greater than 100 words in length and questions in a reading assessment. The researchers theorized that TTS supported comprehension in passages greater than 100 words because the support compensated from lack of comprehension due to reader fatigue and lack of attention.

**TTS support for students with disabilities in core content areas**. In addition to supporting students in assessment, text to speech has also been effective in supporting student comprehension within the classroom. A study conducted by Mooram and Boone (2010) supports the positive effects text to speech has on student comprehension. The researchers utilized the TTS capabilities in the software Read Please to assess whether student comprehension of text increased with the text to speech features. After analysis of data, the researchers noted an increase in comprehension after the students received the treatment of TTS support. In an additional study conducted by Dawson, Venn, and Gunter (2000) also supported TTS as an effective support for student comprehension. In the single subject study, the researchers utilized a computer reading model to support the reading comprehension of a story. When students utilized the computer reading model, comprehension of the story increased in comparison to the teacher reading a comparable text to the student.

**Graphic organizers and aural support.** Although these studies do support the efficacy of TTS on the comprehension of students with learning disabilities, the studies did not assess any specific supports which could be used in conjunction with text to speech features that may provide additional comprehension support for students with disabilities. Additional studies have been conducted which build upon the previous research which support the efficacy of TTS, but evaluate graphic organizers while using text to speech or audio features while reading (Boyle, 2002; Douglas, 2011). In an experimental study conducted with secondary students diagnosed with learning disabilities, the researchers noted that an increase in comprehension occurred when students with learning disabilities read text with audio support; however, when students read text with the support of a printed graphic organizer comprehension strategy, the students comprehension was less than the level achieved from audio support alone (Boyle, 2002). The researchers of the study stated that the graphic organizer may have been complicated and confusing for the student, which decreased their comprehension. Conflicting results were reported from additional studies that utilized paper graphic organizers with the use of text to speech in supporting comprehension.

In a separate study, researchers noted that in comparison to a text and audio only support, providing graphic organizers increased comprehension (Douglas, 2011). In the study, the graphic organizers presented in a simple format and allowed students to transfer printed images from the text to the paper graphic organizer. The students in the study, diagnosed with intellectual disabilities an autism, listened to digital text with the support of TTS and filled in paper graphic organizers. Student comprehension increased when the students utilized the paper graphic organizers paired with TTS.

**Previous measures in comprehension research.** Although previous researchers have determined TTS may support the comprehension of students with disabilities, the research studies include multiple choice format as the measure to determine the level of student comprehension. While multiple choice has the potential to assess student comprehension, often times multiple choice question sets include innappropriate distractors, alternative concepts, a content to mastery mismatch. In addition, students can often guess the right answer based upon the question, which does not reflect a true measure of comprehension.

In Sadler’s (1997) article, which provides a psychometric analysis of multiple choice science questions, the researcher stated that student’s answers to the questions often matched their preconceived notion of the concept. In an astronomy assessment, the researcher conducted an answer analysis for questions that asked about the suns position in relations to the moon. Upon analysis of the answer, the researcher noted that only 12 percent of the students answered the question correctly, with most students selected the multiple choice response that aligned with their alternative conception of the placement. When the question was given to science teachers, 100% of the teachers answered the question correctly (Sadler, 1997). Since alternative conceptions have been held by students for so long, and scientific concepts are difficult to understand, when given the multiple choice format, students often become confused between the correct answer and their alternative conception.

In addition to multiple choice formats providing answer sets that may be confusing to the student due to alterative concept distractors, students also have the opportunity to select the correct answer from a selection set without reading the primary passage by guessing or utilizing verbal reasoning to find the correct answer. In studies conducted with SAT reading patterns and answer selection, researchers determined that students have a high chance of answering questions correctly without reading the passage, and that students are able to answer questions correctly by reading the set of questions (Katz, Lautenshalger, Blackburn, and Harris, 1990; Daneman and Hannon 2001). Therefore, valid multiple choice questions and choices may not consistently measure comprehension, but rather a student’s skill in context and verbal reasoning, depending on their reading patterns while reading the passage. Researchers and educators have advocated the use of open ended questions and alternative assessments, including verbal explanations, as a more accurate representation of student comprehension (Katz; Sadler, 2007).

**Purpose and Research Questions**

TTS can be beneficial in supporting the comprehension of students with disabilities; however, very few studies compare the effectiveness of TTS with dynamic highlighting and digital graphic organizers as strategies to support a student’s independent comprehension. In addition, the employed measures in the studies may have not accurately represented the students’ comprehension. Therefore; the purpose of this study is to determine the effectiveness of graphic organizers and TTS with dynamic highlighting to support the comprehension of students with learning disabilities in a science content area.

1. Does TTS with dynamic highlighting increase the expository reading comprehension of elementary students with learning disabilities?
2. Is there a differential effect between expository text comprehension of elementary students with learning disabilities when accessing digital text with text to speech features with the support of dynamic highlighting compared to utilizing text to speech features with the support of digital graphic organizers?

The knowledge gained from this study may help to build upon previous research of effective strategies that impact the expository comprehension of students with learning disabilities who access the general education curriculum.

**Method**

**Participants**

The participants for this study will be 6 fifth grade students, a combination of male and female, diagnosed with learning disabilities who attend a private day school for students with high incidence disabilities. All students included in the study, although attending a private special needs school, will access the general education curriculum and receive support in specific areas in accordance to their individualized education plan (IEP). Students included were recommended for this alternative program by their neighborhood school and attend the school with no cost to the parent. If on file and administered within a year to the date of the intervention, the comprehension subtest of the Woodcock Johnson Reading Battery will be used to determine the reading comprehension of each student. Prior to intervention, if not on file, the each student will be administered the student will be administered the comprehension assessment of the Woodcock Johnson. (Woodcock, McGrew, Shrank, 2010). The level obtained from the assessment will be used for the text level read by the students during baseline.

**Inclusion/exclusion criteria.** This study will focus on the effectiveness of TTS, graphic organizers and dynamic highlighting as support strategies on the comprehension of expository text of students with learning disabilities. Initial criteria for inclusion will include students in upper elementary school, fifth grade, diagnosed with learning disabilities that are accessing grade level science content. After selection of a school with a population that contains students diagnosed with learning disabilities that access the general science curriculum, the teachers will recommend students whose independent reading impact the comprehension of expository texts and who have low independent scores in comprehension in the science content area. The six students selected for the study will be in the same fifth grade classroom and have similar average reading levels according to Woodcock Johnson reading comprehension subtest and a low independent comprehension average as obtained from independent worksheets assessing science comprehension. Since the current study will determine if TTS and digital graphic organizers are effective supports for science comprehension, only students who have difficulty comprehending science content will be included in the study; therefore, scores from in class informal assessments will be included as a determining factor. Students will be excluded from the study whose reading level was one year or less than their grade level and who had obtained an average of seventy percent or higher on indpendent science comprehension assignments. Students with behaviors that impact their academics, that spend an average of 5 percent or more of the school day out of the class due to behaviors, and students with a secondary diagnosis of emotional and behavioral disorders will be excluded from the study. Students will also be excluded from the study who were diagnosed as having a receptive langauge deficit.

**Setting**

The private special needs day school is located in a suburban neighborhood in Northeastern Virginia. The school serves students in grades one through twelve that have been diagnosed with high incidence disabilities including learning disabilities, emotional and behavioral disorders, and mild intellectual disabilities. The students remain in the same class for the duration of the day and receive grade level instruction in the content areas of reading, math, social studies and science. Each student receives specific remedial support in the areas of mathematics, reading, and math for a percentage of the school day.

All research will be conducted in a computer lab located in a rear hallway of the elementary wing of the school building. Each phase of the intervention, baseline and treatment, will be conducted with only the intervener and the student in the computer lab without distractions.

**Research Design**

This author of the research study will employ an alternating treatment single subject design to determine a relation between two digital supports, dynamic highlighting and graphic organizers with text to speech, on student comprehension. Single subject research is a scientific methdology that documents functional relationships between independent and dependant variables and is specially useful in special education research as it is recommended for the determiation of effective educational interventions and practices for the individual learner (Horner, 2006). Since the participants within the study will be special education students diagnosed with learning disabilities that may have various learning needs, in utilizing single subject research, each student is their own control and the impact of the intervention is determined for each individual student. To compare each treatment, an alternating treatment design will be used. An alternating treatment design will be replicated across participants and be utilized with each participant receiving treatments in different orders, reduceding the potential for any positive relationship and slope to be caused by student maturation. The number of sessions in baseline and treatment were all determined by the numbers recommended within the quality indicators of single subject design (Horner, 2006).

**Dependent Variable**

**Expository Text.** To measure the levels of student comprehension, Harcourt’s Grade 5 Life Science Text, which provides fifth grade content material on a 4.9 to 5.8 grade reading level and corresponding questions will be used. The author will collect text from the Harcourt textbook which had a readability level of 5.2, which will be higher than the students independent reading level, with a passage length ranging from three hundred twenty five to three hundred thirdy four words. The readability levels of the passages will bedetermined by Fleish Kincaid Readability Calculator. The passages will be scanned into Read Out Loud using optical character recognisiton software into a Microsoft Word document. The font size and type used in the program will be 14 point Times New Roman in black font on a white background. No images will be used during the treament.

**Comprehension Measure.** The researchers will develop three open ended comprehension questions for each treatment session; a total of 45 comprehension questions. The researchers will modify questions from the unit comprehension questions from the textbook. The readability of the questions including language, sentence structure, and word choice will be adjusted to correspond within .08 of the students indpendant reading level, so that decoding difficulties during indpenedent reading of the question will not impact the students comprehension score. The modified questions will then validated by two science teachers at the participating school for content. An additional member, a professor of science education, will provide additional validation to ensure the questions did not contain distractors and were neutral in construction to avoid student answers that would contain alternative concepts.

The questions will be typed on a 14 pt Times New Roman Font in black ink, and printed on a 8x10 sheet of white paper for the students completion. Students will be asked to read each question out loud during comprehension assessment.

The researcher will record the number of incorrect words read for each passage to control for any comprehension difficulties that may have occurred from decoding issues. The researcher wil not provide any assistance to the student. The questions and passages will be constant across particiants. An analytic rubric, which will alos be validated by the same expert set, will developed to evaluate the responses of each student.

**Independent Variable**

**Text to speech and dynamic highlighting**. The text to speech (TTS) features paired with dynamic highlighting and text to speech features is one independent variable in the study. TTS is the oral presentation of written text in a digital format, where each word is read on the screen to the student. In Don Johnsons Read Out Loud, a synthesized human voice reads the information on the screen. For the purposes of the study, a male syntehsized voice will be selected for each participant. As the voice is reading to the student, each word is highlighted on the screen.

**Text to speech and** **graphic organizer feature.**Text to speech features will bepaired with the impelemtnation of digital graphic organizers in Don Johnstons Read Out Loud (Johnston, 2013) as a second independent variable. In the digital graphic organizer, which is an existing feature in the Read Out Loud Software, students are able to highlight any text that they think is an important fact, and the highlighted text is then immedatiatley transferred into a graphic organizer.

Immediately prior to the first treatment phase, each student will participate in a breif tutorial of the features that would be used in the program. Prior to moving into treatment, the students will demonstrate the ability to complete all of the following steps with one hundred percent accuracy: turn on the dynamic highlighting feature and text to speech feature, how to reread text, how to turn on the graphic organizer feature, and how to transfer text to the graphic organizer, before moving into treatment.

**Procedures**

**Baseline.** During baseline, students will read a passage from Harcourts Grade 5 Life Science textbook. Using Fleish Kincaid, the grade level of each passage will be calculated, and the indpendant passages should be atleast two grade levels higher than the students independent reading level. The passages and levels will be calculated and collected prior to baseline. The passages will be typed in a Word document, and printed on a white sheet of 8x10 sheet of paper, with a black 14 point Times New Roman font. Each student will read one passage each treatment day, for a total of five passages, or until stability is reached within baseine (Horner, 2006).

To determine passage length, previous research was considered. Although passage length is not a highly researcher area, some research has determined that students have a greater information retention rate on shorter passages, around 300 words in length (Mehrpour, 2004). An additional study determining the impact of TTS on comprehension found that the use of TTS reduced student comprehension when passages are less than 100 words (Dolan, 2005). Therefore, each passage will be in the range of a short passage length, from 275 to 325 words, and the students will immediately answered paper based comprehension questions that were provided after each section of the physical science passage.

The corresponding questions will be pulled from the textbook, and then modified to match the average of the students’ independent reading level. Baseline phase will be completed over five days, with one passage and question set per day. The average time for each session in baseline across participants for will be calcuated and reported in the study manuscript. Students will read the text from the passage and from the question set out loud. The researcher will record words read correctly in the text passages and the comprehension questions.

**Alternating treatments.** The alternating treatments will occur over a span of ten days, with five non consecutive days for each treatment. The author will randomly selected when students will receive the dynamic highlighting and graphic organizer treatment. The treatments will be presented to the students in different orders, so that none of the students received the same order of treatments.

With the dynamic highlighting treatment, the students will only access the text with dynamic highlighting and TTS, which will be turned on by the researcher prior to each treatment. In the graphic organizer treatment, the students will access the text with TTS and complete a graphic organizer with built in headings. The headings on the graphic organizers included main idea and supporting details. To fill in the graphic organizer, students will highlight important facts from the text, which will be immediately transferred into the graphic organizer. The students can highlight any information they found connected to the main idea or supporting facts, and will not bound to finding specific information. The average length of reading time for text to speech and text to speech with the support of the graphic organizer will be calculated. Students will be allotted 10 minutes to read the text and will not be allowed any repeated reading of the text to control for increased comprehension due to repeated reading; however, students will be allowed to pause the TTS feature to highlight text for use with the graphic organizers. Students will utilize the text to speech feature without the use of headphones with an external speaker. Each session will be videotaped. For the comprehension portion, students will not be given a time limit and can read questions again and change answers. Event recording will be used to record the number of correct answers on each comprehension passage.

**Interobserver Agreement**

Data will be collected on a trial by trail basis by two researchers. Each researcher is a graduate student at a univerisity located in Northern Virginia. Both researchers will score the comprehension assessment and review the recorded sessions and calculate the number of words read correctly on each independent comprehension assessment. Prior to observation and assessment of the words read correctly, the researchers will receive training on words that would be counted as incorrect by a elementary reading professer located at the University. Incorrect pronounciations, incorrect words, and omissions will be coutned as errors. Repetitions and self corrections will be counted as correct. The researchers will also received training on the answers that would be counted correctly during the comprehension phase and how to utilize the scoring rubric.

Each participant had a total of 15 sessions, including baseline, with a total of 45 sessions across participants. The first observer will collect data on one hundred percent of the comprehension assessment scores and words read correctly during the oral reading of the assessment. The second intervener will collect data on 40 percent of the sessions, or 36 sessions. Using the formula: agreements divided by agreements + disagreements x 100, the average interobserver agreement for all participants comprehension scores is 100 percent. The final interobserver reliablility will be reported.

**Procedural Reliability**

A procedural checklist will be developed by the researchers to determine the steps in both treatment and baseline that should be followed by the intervener. Each session will be recorded, and the second intervenerwill complete the procedural checklist while viewieng 35 percent of the recorded sessions. Using the formula: dividing steps compbleted by steps planned x 100, the average interobserver agreement will be reported.

**Social Validity.** Each student will be asked a series of questions to investigate the level of confidence the students had when answering comprehension questions after listening to text to speech in comparison to reading independently on paper text. Additionally, students will be asked whether they prefered reading paper text, digital text with speech to text and dynamic highlighting, and text to speech with graphic organizers.

**Data Analysis**

Prior to the treatment phase, the researcher will plot the comprehension scores obtained in baseline. The researcher will wait for stability in baseline exemplified by very little variability between each data point with an average of five data points across participants, prior to moving into treatment. In baseline phase, in addition to the plotting of comprehension scores, the words read correctly of the passage and comprehension questions will be plotted. In the treatment phases, the comprehension scores will be plotted as well as the percentage of words read correctly of the comprehension questions. Comprehension scores will be plotted for the alternating treatments of dynamic highlighting and graphic organizer with the use of TTS. The researcher will visually compared the scores obtained in both treatments to the comprehension scores in baseline across participants. Plotted comprehension scores in each treatment will then be compared across participants and between treatments in each participant. Each participant will receive a dynamic highlighting treatment five times and a graphic organizer treatment five times in random order.

**Anticipated Results**

Through visual analysis, the results should demonstrate a positive relationship between comprehension scores and text to speech with both features in comparison to comprehension scores obtained from the paper text. However, I do not expect any statistically significant relationship to exist between the implementation of graphic organizers and text to speech with dynamic highlighting, as both features have been previously supported by the literature. Additionally, both features support the potential for lack of student attention and decoding issues that impact the comprehension of expository text.

**Discussion**

Previous research suggested that both TTS and graphic organizers may have a positive effect on the comprehension of students with learning disabilities. However, very few studies combined both TTS with specific digital features, including graphic organizers and dynamic highlighting, which have also been found to have positive effects on comprehension. The results from this study should align with previous research, demonstrating a positive relationship between the implementation of speech to text when compared to reading without support. Additionally, the data obtained within the study should demonstrate a positive effect on student comprehension when students utilized both dynamic highlighting and digital graphic organizers. In previous studies when graphic organizers were implemented with audio or TTS features, paper graphic organizers were used and conflicting results were reported. In this study, the results should align with the positive effects of digital graphic organizers in which simple graphic organizers were implemented. The study should also supported the use of digital highlighting as a positive support in supporting the comprehension of students with disabilities.

Although this study should demonstrate a positive effect on student comprehension when students utilized TTS with dynamic highlighting and graphic organizers, the results will be limited in the type of voice used, the program used, length of the passages read, and the content area. Additional research should determine the relationship of TTS with graphic organizers and dynamic highlighting in other programs, disability areas, and grade levels.

TTS with the dynamic highlighting and graphic organizers as a built in feature may have a positive effect on student comprehension of digital texts. However, although beneficial, the complexity of the graphic organizer may impact student comprehension negatively. By providing two methods of support through dynamic highlighting and the students’ creation of graphic organizers while reading, the student will be engaged with the text and receive the auditory support that may have compensated for any decoding issues, which may have positively affected student comprehension of expository text.

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