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Hearing Math: Algebra Supported eText for Students With Visual Impairments

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Supported eText for students with visual impairments in mathematics has a promising, emerging literature base, although little of the existing research focuses on implementation within a classroom setting. This qualitative study sought to understand the use of supported eText to deliver algebra to students with visual impairments enrolled in algebra mathematics courses. The study also sought to explore supported eText in contrast to students' traditional means of accessing an algebra text. The main results suggest supported eText holds potential in terms of delivering mathematics content; however, more research and more reflection on the field is needed regarding this approach as a sole means of presenting text. Implications for teacher professional development and implementation practices are discussed.

Keywords: eText, disability, mathematics, visual impairment

Digital text (eText) is text or materials presented or read on a computer or similar device (Anderson-Inman, 2009; Freed & Rothberg, 2006; Hatlen & Spungin, 2008). In other words, eText is simply textual materials presented electronically or digitally (Anderson-Inman & Horney, 2007). Supported eText is digital text that is modified or enhanced in ways designed to increase comprehension and promote content area learning (Anderson-Inman, 2009; Anderson-Inman & Horney, 2007). Anderson-Inman and Horney (2007) situated 11 types of supportive resources that can serve as eText support: presentational, navigational, translational, explanatory, illustrative, summarizing, enrichment, instructional, notational, collaborative, and evaluative. In other words, supported eText allows digital text to be rendered in multiple ways (e.g., speech, video, and Braille) while also providing cues, such as color and size of font, zooming, comprehension aids (i.e., notes), and hyperlinks (Anderson-Inman, 2009; Anderson-Inman & Horney, 2007; Horney et al., 2009). The versatility of supported eText allows this technology to support not just literacy but other content areas, such as mathematics (Bouck, Joshi, Meyer, & Schleppenbach, 2013; Bouck & Meyer, 2012).

Students with visual impairments (VI) are targeted consumers of eText (Freed & Rothberg, 2006; Hatlen & Spungin, 2008). The National Instructional Accessible Materials Standards in the Individuals with Disabilities Education Act (IDEA; 2004) stipulated students with print disabilities—inclusive of students with VI—should receive access to accessible textbooks, including digital textbooks (Emerson, Corn, & Siller, 2006; National Center on Accessible Instructional Materials, 2011). eText is increasingly becoming a preferred format for providing accessible text given the challenges with other alternative modes of presentation (Fichten, Asuncion, Barile, Ferraro, & Wolforth, 2009). For example, Braille text presentation can be challenging given (a) a decline in Braille literacy among students with VI, (b) the amount of time Braille textbooks can take to produce, and (c) the errors found in Braille textbooks from translation (Bouck et al., 2013; Dick & Kubiak, 1997; National Federation for the Blind, 2009; Toussaint & Tiger, 2010). Large print textbooks also can provide frustration to students if not produced in color and the text references color, or are not accessible for the students when school starts (Bouck et al., 2013; Emerson et al., 2006). Even eText can be limiting to students with VI. Scanned text, books on tape, or just using basic text-to-speech can result in pacing issues, ambiguity with understanding mathematical language, and errors in translation (Dick & Kubiak, 1997; Landau, Russell, Gourgey, Erin, & Cowan, 2003; MacGregor & Price, 1999).

Although supported eText is most commonly associated with literacy and more reading-intensive content areas (e.g., science; Anderson-Inman, Terrazas-Arellanes, & Slabin, 2009; Horney et al., 2009), it can also support students with VI in mathematics (Bouck et al., 2013; Bouck & Meyer, 2012). However, eText in mathematics for students with VI is more complicated, particularly as the mathematics becomes more complex (i.e., algebra; Landau et al., 2003; MacGregor & Price, 1999; Power & Jürgensen, 2010). In mathematics, the text to be read is not just the English language (i.e., narrative text), but also mathematical language (e.g., exponents, fractions, and equations). Mathematical language can be ambiguous without clarification as to the interpretation (Landau et al., 2003; MacGregor & Price, 1999; Power & Jürgensen, 2010). For example, consider hearing the expression x plus 3 over y. One could interpret the expression as $\frac{x+3}{y}$ or $x + \frac{3}{y}$. A typical screen reader usually treats mathematics expression as an image (Archambault, Caprotti, Ranta, & Saludes, 2012; Cooper, Lowe, & Taylor, 2008). However, describing an expression as an image becomes less effective

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when expressions become more complex and semantic cues are needed (Alajarmeh & Pontelli, 2012; Cooper et al., 2008).

Despite the increased attention to eText is the literature; little research actually exists on the use of eText in mathematics for students with VI (Anderson-Inman, 2009; Bouck et al., 2013; Bouck & Meyer, 2012). Among the limited literature, Alajarmeh and Pontelli (2012) investigated the effectiveness of MathPlayer—a mathematical text-to-speech software that supports rendering algebraic equations (i.e., using MathML language) and provides cues to help students manipulating algebraic equations. The study showed the accuracy of solving algebra equations (i.e., fewer mistakes made) and time spent on equations were better for the five secondary students with VI with the technology than their conventional ways (i.e., CCTV or Braille writer). In another study, Bouck et al. (2013) found supported eText in algebra yielded positive effects in understanding and accessing algebraic expressions for students with VI. Bouck et al. (2013) examined the presentation of algebraic expressions of varying levels of difficulty (i.e., monomials, as well as polynomials, each with fractions, decimals, and exponents) through the supported eText player ReadHear, which uses MathSpeak language to orally present mathematical equations and expressions (gh, 2006). Bouck et al. (2013) determined the potential for such supported eText in mathematics in terms of students understanding the presentation of algebra as well as students' interest in using the technology.

Despite the promising, emerging literature on using supported eText for students with VI in mathematics, little research exists in a classroom setting (Bouck & Meyer, 2012). Using a qualitative-based research approach, researchers sought to understand the use of supported eText to deliver algebra content to students with VI in mathematics classes. To address this goal, the researchers attempted to answer the following research questions:

> How does a supported eText technology support secondary students with VI in algebra?
>
> How does use of the supported eText technology compare to students' traditional means of accessing a textbook and instruction?

Method

Participants

Five high school students with VI participated in this study. The five participating students all met the following criteria: (a) identified as having a VI, including low vision or blindness; (b) enrolled in the State School for the Blind where this study occurred; (c) comprehended and spoke English; (d) enrolled in Algebra I or Algebra II; and (e) obtained consent and assent to participate. All of the participating students resided at the State School during the week and returned home on the weekends (see Table 1).

Teachers

Two teachers, Jill and Renee, participated in this study. Both taught secondary mathematics courses at the State School for the Blind and were certified mathematics teachers for the visually impaired. Renee was in her first year of teaching at the school and Jill within five years. Renee taught two courses for the school during the year of the study but taught them from a distance (i.e., remotely). In fact, the school referred to her as the "teacher in the box." Specifically, Renee taught her classes from her home in another state via technology, although a paraprofessional was physically present to address any issues arising in the class as well as do day-to-day activities (e.g., pass back paper). She appeared on a large television at the front of the classroom for each class; the screen was also equipped with a web camera so Renee could see the students in the classroom. Renee and the participating students also communicated via software; they used using Microsoft Lync to transfer documents, chat online, and share computer screens. Caleb and Sarah also used Perky Duck to create Braille files on their computers. Renee had three students participating in the study, all from her Algebra II class. Jill was a secondary mathematics teacher of students with visual impairment at the State school. She offered face-to-face mathematics classes, including Algebra I, Algebra II, geometry, and pre-algebra as well as supported students with independent studies in more advanced mathematics (i.e., calculus). Jill typically relied on the textbook for teaching. For the purposes of this study, two students of Jill's—each from a different class—participated in the study. Each student was enrolled in Algebra I.

Setting

This study primarily occurred in students' respective mathematics classes. Kelsey and Chad were observed in Jill's mathematics classroom, although at separate periods; Caleb, Sarah, and Dana were all observed in Renee's classroom for the same period. During the sessions with traditional presentation, Kelsey and Chad sat at a table facing a board and when the text was presented via ReadHear they both sat at the computer area but used project laptops. Renee's classroom consisted with two rows of tables facing a large flat panel television located in front of the classroom. Each row contained a desktop computer, a project laptop and a Braille notetaker per seat. Renee was projected on the television at the front of the room.

In addition to the classrooms, a small portion of the study occurred in the school's library. The researchers worked one-on-one with students during the interviews and training in the library. In the library, all students worked at a table with a researcher on a research project computer. The two researchers were in separate areas of the library—one in a small conference room and one within the main part of the library.

Materials

ReadHear

ReadHear is a supported eText software player produced by gh, LLC (2011). ReadHear can read Digital Accessible Information System (DAISY) Digital Talking Books (DTB), National Instructional Materials Accessibility Standard (NIMAS) files, and MathML-embedded format (gh, 2006). ReadHear uses MathSpeak, an output language to translate MathML (i.e., an input language used to code mathematics content) to diminish

Table 1. Demographic and study information about participants.

	Chad	Kelsey	Caleb	Dana	Sarah
Gender	Male	Female	Male	Female	Female
Age (years)	18	16	19	18	17
Grade	12	10	12	11	12
Visual impairment	Low vision (Achromatposia)	Low vision (light perception in right eye and 20/800 in left eye)	Blindness (only light projection)	Low vision (congenital nystagmus, high myopia, and cortical cataract)	Blindness
Accommodations	Glasses; large print	Large print; enlarged computer screen software	Braille; refreshable Braille display; text-to-speech	Large print; zooming computer screen software	Braille; refreshable braille display
Weschler Adult Intelligence Scale, 4th ed (WAIS-IV)	82 perceptional reasoning; 86 working memory; 84 processing	—	—	—	—
Woodcock-Johnson III	86 overall; 63 mathematics	99 overall; 93 in mathematics	—	105 overall; 104 in mathematics	120 overall; 106 in mathematics
Weschler Intelligence Scale for Children (WISC)	—	—	102-115 verbal; 100-113 working memory	—	—
American College Test (ACT)	15	N/A	18	18	21
Math course	Algebra I	Algebra I	Algebra II	Algebra II	Algebra II
Teacher	Jill	Jill	Renee	Renee	Renee
Accepted into college	Yes	N/A	Yes		
Future career goals/interests	Chef, mechanic, or park ranger	—	Digital music industry, criminal justice, or psychology	—	—
Number of sessions observed	10 (3 RH and 7 T)	12 (5 RH and 7 T)	9 (5 RH and 4 T)	9 (5 RH and 4 T)	10 (6 RH and 4T)

Note: RH = ReadHear (supported eText); T = traditional textbook; — = data not found in students' files.

the ambiguity of mathematical content for students with VI (Steinman, Kimbrough, Johnson, & LeJeune, 2004). Other key features of ReadHear to enhance accessibility and individualization for students with VI included: (a) choices of synthesized voices; (b) color adjustment for background, text, highlighting, and tracking; (c) speed and volume control; (d) up to 16X zooming screen; and (e) multiple navigation modes (e.g., by word, sentence, chapters, and pages (gh, 2006).

Mathematics Text

The school used textbook—*Algebra I* published by Glencoe McGraw-Hill (Holliday et al., 2008)—was used in the study. Specifically, the study involved chapter 9, "Quadratic and exponential functions." The teachers selected chapter 9 because no student in the study previously received instruction on the content—quadratic or exponential functions—regardless if she or he was in Algebra I or Algebra II. The chapter consisted of 6 sections: 9-1 Graphing quadratic functions, 9-2 Solving Quadratic function by graphing, 9-3 Solving quadratic equations by completing the square, 9-4 Solving quadratic functions by using the quadratic formula, 9-5 Exponential functions, and 9-6 Growth and decay.

Computer and Video Equipment

Five Dell laptops were used in this study. Each laptop came with a built-in camera and was equipped with a screen capturing software (i.e., Camtasia; TechSmith®, 2012) to capture students' use of the technology on the laptops throughout the study. Each computer was also installed with the ReadHear software. Other accessories, such as headsets, mice, standard keyboards, and Braille note takers were provided to students based on their preferences and needs. In each classroom, there was also a Sony camcorder attached to a tripod to record the teaching of chapter 9.

Procedures

This study employed a qualitative research methodology to explore how students accessed and learned as well as how teachers delivered mathematics content when using the supported eText player (i.e., ReadHear) and then when using students' traditional textbooks. Data were collected through interviews, observations, online surveys, and artifact analysis (Bogdan & Biklen, 2008).

Training

Each of the participating students underwent one individual training session regarding the technology. During the training session, researchers demonstrated features of the ReadHear technology, as well as the MathSpeak language. Students were also provided opportunities to navigate through key features on ReadHear and select their preferences relative to reader voice, book voice, speech rate, volume, zoom, contrast, text color, font, panning, and tracking, as well as colors for contrast and tracking. Student's preference settings on ReadHear were documented by the researchers and used during the intervention sessions. In addition, students were taught to use common navigation functions using keyboards or mice. The training sessions were captured via videotape and screen recording software (i.e., Camtasia). Training was complete when students completed all aspects and demonstrated independence in using all the features of the technology.

Interviews and Online Survey

Researchers interviewed students one-on-one prior to the start of the study; interviews were also video recorded. The semi-structured interview protocol contained three parts: 4 questions about ReadHear, 11 questions about mathematics and technology, and 13 likert-scale statements about mathematics, textbooks, and supported eText (see Figure 1 for additional information). SurveyMonkey (http://www.surveymonkey.com) was used to distribute 10 preintervention and 9 postintervention online survey questions. Educators at the school recommended researchers use SurveyMonkey to gain the information due to the site's compatibility with screen readers (refer to Figure 1).

Section Content and Assessments

All students completed six sections of chapter 9 of an algebra book; three of the sections (i.e., sections 1, 3, and 5) involved

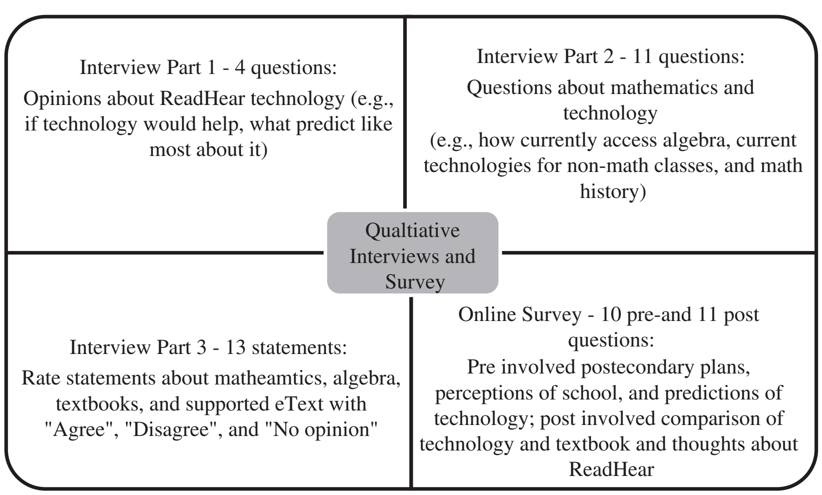

Fig. 1. Qualitative interviews and surveys.

the text being presented with ReadHear and the other three sections (i.e., sections 2, 4, and 6) involved text being presented through students' traditional textbook. Each chapter section was completed within one to three class periods depending on students learning and teachers' teaching speed; all six sections were completed in six weeks of instructional time. Note, part of the length of the study involved days missed due to the school's schedule, including half-days on all Fridays and special events (see Table 1 for number of observations per each participant). After each student completed a section, she or he was given a five-question assessment based on the content from the section. Each assessment reflected the content from the section and students completed the same assessment for each section. Students were provided the assessment in an accessible manner—large print or Braille, depending on their individual needs.

Observations

Observations of mathematics teaching with the chapter 9 of the textbook were conducted in both classrooms by the researchers and involved both face-to-face observations as well as retroactive fieldnotes taken from video recordings of both the classrooms (i.e., a video camera) and students individual computers (i.e., Camtasia).

Data Analysis

Data (interviews, surveys, fieldnotes, researcher reflection notes, and mathematics assessments) were read and re-read to answer the research questions. Data analysis began by organizing the hard copy of the fieldnotes, interviews, surveys, and mathematics assessments in chronological order. Researcher then read the hard copy of the data notebook and noted patterns, and then condensed and expanded the patterns emerging to create themes. Key and/or typical analytical vignettes as well as interview or survey quotes were located within the data to support assertions (Bogdan & Biklen, 2008). Triangulation was sought among the multiple data sources. Independent observations formed the main source of the data and interviews and surveys were used to support or challenge what was observed. For the assessment data—used in triangulation—for each assessment, researchers calculated the number of questions each student solved correctly as well as the number they attempted. Accuracy was calculated by dividing the number of questions answered correctly by the number attempted as well as the number possible. Some of the questions contained two correct answers (e.g., two roots); if students answered only one of the answers correctly, they received partial credit (i.e., 0.5 points).

Results

Three main themes emerged from the data: (a) the confusion between teaching and technology, (b) the consideration for whom the technology works, and (c) the affordances and constraints of the technology.

Confusion between Teaching and Technology

Throughout the study, confusion emerged surrounding the technology and how the technology intersected with how the teachers taught. For both teachers the supported eText was not treated as an integrated part of their teaching but as a stand-alone way of delivering the content. In fact, Jill did not even teach the sections students accessed through the supported eText—unless to review—and even referenced the technology as akin to an online course. In other words, Jill treated the supported eText as a means of instruction rather than a textbook; the supported eText regardless of its features (e.g., text-to-speech and image descriptions) was only a digital version of the textbook providing the content and visual information in the hard copy. For example, one day when discussing the technology with Chad and Chad expressed his frustration that the digital talking book did not teach him like when his teacher was in front of him explaining, Jill commented, "But for math and science, it will be realistic for you to say I wouldn't do those classes online" (via fieldnotes).

Similarly, Renee tried to establish the presentation of the supported eText as an alternative to her lecture, stating, "Instead of having to listen to me blah, blah, blah on, you are going to listen to this. I would like you guys to take notes if you can while you are listening" (via fieldnotes). She established the ReadHear as a teaching tool rather than a textbook and referenced students back to the technology rather than presenting the material when they had a question (via fieldnotes). Renee also commented that use of the technology was challenging to her because of her lack of involvement, saying "It is hard for me with this way because I don't do the session with them so I am like wait a minute and playing catch up" (via fieldnotes).

The students also expressed confusion over the role of the digital textbook. For example, some of the students commented that the technology did not teach them and it was very different than having a teacher explain the mathematics and work one-on-one with them. Students' view of the digital textbooks as more than a textbook was expressed in individual interviews or surveys. For example, Kelsey stated, "Whenever I would talk to the teacher, she would explain what each thing means in detail and show me tricks to remember things. The computer only reads the material and doesn't have any advice or any reminders" (via survey). Kelsey also offered, "Math is a very hard subject to learn when you only have a book and no teacher" (via survey). Similarly, Chad stated, "I would have liked it [digital textbook] better if there was more explaining and examples" (via survey) and "I am not a big fan of doing math with a screen reading program mainly because I cannot communicate with it and ask question" (via survey).

The confusion students faced was also evident by limited student engagement with the mathematics they read with ReadHear. Both Chad and Kelsey only attempted a couple of problems during chapter 9, section 1—the first instance of using ReadHear to present the text, but after that they did not attempt any examples using paper and pencil or even stop to complete a "check your progress" problem. In contrast, Kelsey worked out the problems Jill presented to her from the text. As a result, Kelsey felt she did not understand the information when presented via ReadHear. For example, when asked by Jill if she remembered factoring, which was presented in section 9.1 of the text, Kelsey replied, "Which I wasn't even learning" (via fieldnotes). Jill retaught chapter 9, section 1, to both Chad and Kelsey prior to teaching chapter 9, section 2.

In contrast, there were some levels of engagement with the supported eText from the three students in Renee's class. For example, one day when Caleb was struggling with a particular problem when using ReadHear, Renee directed him to an example in the supported eText and he and Renee worked through the example together. They used the supported eText—with Caleb listening to it a few times himself prior to asking Renee—to discuss the material. However, there were also times—such as with chapter 9, section 5—when Caleb raced through the reading, such as completing the entire section in 10 minutes, which suggests a lack of interaction with the examples. Sarah, on the other hand, paused the supported eText while it read examples and typed notes into her Braille notetaker. Similarly, Dana also paused the supported eText and relistened to equations, take notes, or try an example problem.

For Whom It Works

Supported eText—in this case ReadHear—was designed to support students who struggled to access printed traditional text (Anderson-Inman, 2009). According to the NIMAS (National Center on Accessible Instructional Materials, 2011), accessible textbooks are to be made available to students with print disabilities, inclusive of students with VI. However, this type of technology was not for everyone regardless of classification as having a print disability. Many other facets were at play in considering for whom the technology work, including the division between low vision and blind, aural and visual learners, and student preferences.

The technology—including the program and the mathematics language that was read (i.e., MathSpeak)—was designed primarily for students who were blind, which represented two of the five participants in this study. Because the MathSpeak language is based on the Nemeth code (gh, 2006), students with low vision who were not previously exposed to the construction or representation of mathematics in that manner reported some confusion. For example, Chad—a student with low vision—repeatedly expressed his concerns with the language. One day during instruction with the traditional textbook Chad discussed the technology with his teacher, stating, "It is just for me, when they switch to different terminology, for me, I get confused because I am not a Braille person so sometimes when it is superscript, I am like huh?" At a later date, Jill indicated, "What they need to do is a tutorial on how to listen with this because low vision students are not Braillers. So you need to be told when we say 'frac' that means fraction. We say sup [superscript] that means exponent. Because I say you know they [students who use Braille] are used to reading it on their own" (via fieldnotes).

And yet, it was not just students with low vision who struggled to use ReadHear. Sarah—a student who is blind—struggled a great deal with the technology. One issue was the different hotkeys with the supported eText player than her traditional other programs—such as JAWS, which caused her a great deal of frustration, especially in the beginning of the study. Another example of why the supported eText was not as effective for her—evident from her statement of "If I am doing this for an actual assignment, I will fail. It is so hard for me to understand"—may be that it was the first time she heard equations presented via text-to-speech. Throughout her use the supported eText, Sarah frequently changed speeds, often slowing down for the equation and speeding up for the narrative. She remarked on the challenge of trying to hear two different types of materials with one speed, "For me, if I slow it down, it is so slow so its hard for me to understand . . . its like I cannot find that speed. I cannot understand a thing. I got bits of pieces of it but [sigh]" (via fieldnotes).

Finally, students themselves identified for whom the technology works—noting their preference as aural or visual learners. Sarah—who used Braille and often struggled with the ReadHear program—clearly expressed her preference for reading rather than hearing information. In response to the question, If you could would you rather use the technology or your typical method?, Sarah responded, "I would rather use my typical methods. Anything is easier for me to understand if I read it." She also stated, "My typical method was more affective [effective] because it's easier for me to learn from reading something than having it spoken to me" (via survey). In contrast, Dana—a student with low vision who used large print and did not appear to have difficulty with the technology—expressed support for the technology, "It [ReadHear] allowed me to fallow [follow] along," "yes, it [ReadHear] was easy to understand, mostly because when I look at something new sometime hearing it helps me to get the explanation better," and "yes, I would continue to use the technology because it did help, mostly I was able to actually know what an equation or expression was with have a hard time figuring out what it reads" (via survey).

Beyond just students' reporting if the technology worked—all students felt their traditional textbook was more effective, except for Dana who indicated it depended on the context—and researcher observations exists another source of data: assessment scores (see Table 2). Outside of Chad, all students correctly answered, on average, more problems attempted with the traditional textbook presentation than the supported eText. However, the students attempted more problems following the sections presented with ReadHear as opposed to the sections presented with their traditional textbooks (65 vs. 62, respectively).

Constraints and Affordances

Supported eText for algebra presented constraints and offered affordances to the students. Having an algebra text presented via the supported eText with MathSpeak language represented a different way of text presentation and resulted in some constraints or challenges for students. For some, it posed a new challenge of learning—not just were students faced with learning the mathematics but also the technology to access the mathematics as well as a new mathematical language. As from what was previously mentioned, the supported eText presented challenges to students already familiar with other software for students with visual impairments, such as JAWS. Some of the hotkeys for the supported eText technology were inconsistent with JAWS. For example, in JAWS, the up and down arrows allows the previous and next lines to be read; whereas in ReadHear, the up and down arrows change navigation modes (i.e., text repeated or moved [skip or forward] via each word, each sentence, each page, or headings). As a result, when Caleb and Sarah tried to navigate

Table 2. Student assessments scores.

	ReadHear (9.1)	Traditional (9.2)	ReadHear (9.3)	Traditional (9.4)	ReadHear (9.5)	Traditional (9.6)
Chad						
Number Attempted	5	3	5	5	5	5
Accuracy	1 (20%)	1 (33%)	1 (20%)	0	2 (40%)	0
Kelsey						
Number Attempted	5	5	5	5	5	5
Accuracy	1 (20%)	0	0	0	2 (40%)	4 (80%)
Dana						
Number Attempted	5	5	5	5	5	5
Accuracy	4 (80%)	4 (80%)	5 (100%)	5 (100%)	2 (40%)	4 (80%)
Caleb						
Number Attempted	0	4	5	0	5	5
Accuracy	—	2.5 (63%)	3.5 (70%)	—	2 (40%)	4 (80%)
Sarah						
Number Attempted	0	5	5	5	5	0
Accuracy	—	4.5 (90%)	4 (80%)	1 (20%)	1 (20%)	—

Note: — = data were not available to compute accuracy.

backwards and forwards within the supported eText they often ended up accidentally changing navigation modes—to their own frustration.

Students also felt conflicted with the lack of physical text in front of them and at times wanted a textbook . Caleb expressed this sentiment at the end of the study, "The main issues I had was that no matter how much you describe a graffic [graphic], it's not the same was having it front of you" (via survey). He stated that he would use supported eText in the future but with the combination of Braille graphics. The issue of graphics was noted by many of the students. For Dana, the graphics was a point of contention and why she felt she would prefer both the supported eText and the physical text, "If I had a choice I probably use a combination of both, mostly because I would be able to fallow [follow] a long better at a graph in an actual textbook" (via survey). Kelsey also struggled with graphs with the technology. At times a graph would be larger than the computer screen when she used zoom. This created frustration as the technology prevented Kelsey from scrolling to see the whole graph. While initially she tried to view and understand the whole graph, after three attempts Kelsey quit and did not take an active role in exploring the graphs in the future (via fieldnotes). Outside of graphics, Kelsey also struggled with seeing the equations, which were a lighter font shade. She stated, "When it comes to reading equations the text is really light. I was going like what? If it is like the print [narrative text], I will be able to see it" (via fieldnotes).

In terms of affordances, the technology offered many including quality, ease, and control of their learning. As for quality, students who used Braille books remarked on the low quality of their traditional copy. For example, when teaching chapter 9, section 2 (traditional text), Renee referenced students to a particular graph only to have the student acknowledge "The line is so smooshed together; it is hard to tell that" (via fieldnotes). Dana also spoke of the quality of the text but from a large-print point of view. Dana noted the print would fade in the large-print version and "even though its large print its still seem small and it makes it had to read exponents or fractions or the positive and negative signs" (via survey).

Ease was another factor students noted with the technology as compared to traditional text, with ease including such aspects as the number of volumes for a Braille text as compared to small print, and the related aspects of feasibility to the number of volumes and space Braille subsumed. For example, during the second day of Renee presenting chapter 9, section 4, she told her students to look at and read an example in their traditional text. Moments later Caleb asked, "How long is this example?" and later "This is long. They take up a lot of pages" (via fieldnotes). Caleb clearly described a benefit of the technology as just a practical reduction in materials, "It [ReadHear] eliminates the need to carry two or three volumes of Braille with you at once, especially in college" (via survey), as well as "Traveling is hard for me to carry two or more math books with airport security . . . plus my laptop, plus my Braille note, plus anything I need for that week" (via interview).

Beyond portability were the ideas that the technology was more cost-efficient and better prepared students for the future. Caleb noted the potential benefits of the digital textbook when he first engaged with the technology, stating in response to if it would help him, "Yes! With the math book, there is cost involved. There is [*sic*] people to explain the graphics involved . . . But this, it is a little more straightforward, a lot less space taken out. A lot more organized" (via interview). Caleb also noted that using computers to present textbooks was likely to be a big part of this future at college. Finally, students indicated the supported eText provided them a sense of control over their learning and access to the mathematics. For example Kelsey stated an advantage of the supported eText was "I would be able to take notes at my own pace and learn at my own pace (via survey). Other students, such as Caleb appreciated its features with regards to control, such as the different navigation modes, "The fact you can control it word for word or sentence for sentence. That way if you missed something, you can actually go back and check it and not all from the start of the beginning" (via interview). This similar sentiment was also noted by Sarah, "The program has several ways to navigate, so words or phrases can be repeated as many times as necessary" (via survey).

Discussion

The main results of this study suggest supported eText holds potential in terms of delivering mathematics but not without limitations and reflection on this approach as a sole means of presenting text; additional research is needed to understand the use of supported eText for mathematics with students with VI. This study as well as previous studies (see Bouck et al., 2013) supports the potential for eText materials in advanced mathematics. However, research regarding supported eText needs to go beyond providing access but include also include outcomes. In that regard, there was some comparable demonstration of understanding after reading the algebra sections involving the two different text presentations: the assessment averages across the 5 students was 43.9% correct out of the problems attempted with the supported eText and 48.4% for the traditional text presentation. However, less than 50% correct answers across a chapter should not be acceptable regardless of textbook presentation mode.

The observation and interviews revealed a more complicated picture regarding the use of supported eText. For one, supported eText was generally not viewed as a digital textbook but as a digital teacher. Although neither teacher just gave students the physical textbook and asked them to teach themselves that is essentially what each did with the supported eText. Although the supported eText orally read the text—and highlighted the text as it read as well as could be easily reread—the only information conveyed was what was in the book. Additional comments, suggestions, and instructional strategies were nonexistent with the supported eText.

Although it is evident that these teachers needed additional professional development regarding the technology, the lack of meaningful integration is not surprising; the lack of meaningful technology integration is a struggle in education as a whole and teachers often conflate technology and delivery mode (Cuban, Kirkpatrick, & Peck, 2001; Ertmer & Ottenbriet-Leftwich, 2010). Yet, it is imperative for the field to reflect if the future of the conversation regarding digital text continues to be an either/or—as in digital text or printed text (large print or Braille)—or rather a both. Although the data suggest students were able to access the algebraic material—and understand to some degree (refer to Table 2)—digital text did not come out clearly ahead in the either/or debate. The technology holds promise but its potential may not be replacing printed text but supplementing, at least at this time. Although additional research is needed regarding the use of supported eText in mathematics for students with VI, practice should not halt until that is complete. Experience with eText text in secondary school is likely to benefit students with VI who are more likely to access this from of technology in higher education (Reed & Curtis, 2011).

Implications

One implication of this project is need for teacher training. Teachers need a clearly articulated understanding that supported eText is a text and not an instructional approach; if teachers would not have students read a traditional text to themselves and be expected to learn algebra, then they should not expect learning to occur just from listening to a digital text. Similar to all technology, teachers need to be trained on how to effectively implement the technology (Ertmer, 1999; Judge & Simms, 2009). General training on digital textbooks, supported eText (e.g., ReadHear), and even any special language with the technology (e.g., MathSpeak) is insufficient, training needs to focus on how to use the technology within the content (i.e., algebra) for one's pedagogical approach and situated within one's context (Ertmer & Ottenbreit-Leftwich, 2010; Mishra & Koehler, 2006).

Another implication pertains to student access to the technology. In this study, students only had access to the supported eText during class time as the technology was installed on project computers and not students' individual computers. If teachers are to effectively use such technology and to do so in place of traditional textbooks, students need access to such technology outside of class time not just during class. In addition, students need access to assessments in the same manner as the text, such as digitally. The need to access digital texts with the approach of supported eText, such as ReadHear, forces schools to rethink how they will distribute and make available such technology to students.

A final implication of this study pertains to incompatibility of the technology used in this study, which will likely influence implementation of the ReadHear technology. The inconsistent keystrokes between the technologies (i.e., ReadHear and JAWS) creates a barrier to usability, not to mention frustration on behalf of the student user. Compatibility between programs targeted to students with visual impairments is essential, and incompatibility should be unacceptable. Previous conflicts between JAWS and other technology programs to support students with disabilities exist (Angelocci & Connors, 2003). For example, Angelocci and Connors (2003) evaluated writing assistive technology software for their compatibility with JAWS and found disconnects, including the inability of JAWS to read text within the programs, keystrokes that did not work within programs, and dual reading of text by both programs. However, ownership for the incompatibility issue should be addressed by both technology developers. The developers of ReadHear should give consideration to keystrokes that mirror JAWS, given JAWS is a common technology for students who are blind (Freedom Scientific, 2013). Likewise, the developers of JAWS may need to update their program.

Limitations and Future Directions

All research involves limitations. A limitation of this research pertains to the different type of classroom of the two teachers in terms of face-to-face instruction and a more distance education-based approach. An additional limitation involved the limited time to employ the technology—in terms of only one chapter of a textbook. Incomplete assessment data for three of five students was an additional limitation, and it is unclear if the assessments were misplaced or the students did not complete the assessment when the entire assessment was missing. Finally, the use of Camtasia or video cameras to capture data may be seen as a limitation to the research.

Future research needs to continue to explore use of supported eText in mathematics classes for students with VI, especially with regards for an entire course. Future research should evaluate how supported eText is implemented—replacement or supplement for traditional text—and the impact of such implementation. In addition, there is a need to understand how use of supported eText impacts the mathematical performance for students with VI; future research should compare student mathematical performance when accessing the mathematics via supported eText and traditional means.

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