INVESTIGATING THE PATTERNS OF TEXT-TO-SPEECH SOFTWARE USE BY
ADOLESCENT STRUGGLING READERS: AN EMBEDDED MULTIPLE CASE STUDY

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAI‘I AT MĀNOA IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

EDUCATION

DECEMBER 2015

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Keywords: Text-to-Speech, Adolescent, Struggling Reader, UDL, AT
Dedicated to

Isla and Toma
ACKNOWLEDGEMENTS

Writing the dissertation was one of the best learning experiences in my graduate experience. I would not have been able to complete the dissertation without the contributions and support of many people.

I sincerely am grateful for my advisor, Dr. Cecily Ornelles. Cecily, I was lucky to have gotten to know you in the one trip to American Samoa, and I was even luckier to have had you as my advisor. You were my sounding board, and your advices on child rearing on top of my dissertation were much needed. Thank you for telling me to take my time to be with my children at the same time as believing that I can balance all and move forward with the doctoral program.

I would also like to thank my committee members, Drs. Robert Stodden, Kelly Roberts, Kavita Rao and Michael Salzman, for their support, encouragement, input and understanding. I had the best dissertation committee with the scholars I admire the most.

This dissertation was also not possible without the works of the Steppingstones: Text-to-Speech Phase II Study funded by the U.S. Department of Education, Steppingstones of Technology Innovation for Children with Disabilities (Award # H327A100090-01) led by Drs. Stodden and Roberts at the Center on Disability Studies. Thank you to all research staff, schools, teachers, and students involved in the study with special thanks to Jin and Kendra without whom I would not have been able to decipher all of the data.

I would also like to thank the opportunity and funding received through the Pacific Region Special Education Leadership Training Project (Award #H325D10070) with the lead of Dr. Mary Jo Noonan.

I am also thankful to all my staff and colleagues at the Center on Disability Studies for their understanding when I was not as readily available at times during the past few months. Thank you all for supporting me to attain my goal.

Finally, I truly appreciate my husband who always tried to figure out a time for me to study and write. Thank you, Philip, for letting me take this path. I would not have been able to complete without you running after our little monkeys and being not only their dad, but also their mom when I was too busy to be one.
ABSTRACT

This embedded multiple case study investigated how text-to-speech (TTS) software intervention was effective in improving the reading comprehension outcome of struggling adolescent readers by analyzing the patterns of their TTS software use (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tools use). The patterns were examined for students who made high gains (HG), moderate gains (MG), and no or negative gains (NG) on their pre-post reading comprehension score as measured by Gates MacGinitie Reading Test. Twelve cases, four cases from each of the groups, were selected from 165 intervention group students of a large randomized controlled study on the efficacy of the TTS software intervention. Students were all ninth grade students reading at least two-grade level below their actual grade. Radar charts were utilized to visually analyze the overall patterns of the TTS software use within and across cases. The results of the study showed that there was no specific pattern of the TTS software use by reading gain groups. However, distinct patterns of the TTS software use emerged at the teacher/class level. The results suggest that the overall students’ patterns of TTS software use were highly influenced by the teachers’ delivery, task choices and their previous experience in using the TTS software. Further cross-case examination of students’ perceptions and attitudes towards using the TTS software revealed reading gain group differences: More NG and MG students reported difficulty understanding the text using the TTS software compared to the HG students who expressed no difficulty. The paper concludes with recommendations for teachers to consider in implementing the TTS software intervention, limitations of the study, and future directions.
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CHAPTER 1
INTRODUCTION

Historically, research along with state and federal initiatives pertaining to improving reading have focused on primary grades to prevent future reading failures (Edmonds et al., 2009; Moats, 2001; National Institute of Child Health and Human Development [NICHHD], 2000). Despite such efforts in prevention, few actual improvements in the outcomes of older students are seen (Faggella-Luby & Deshler, 2008). The reality of the students’ reading outcomes in the U.S. school system today is that there are more students in secondary grades who are reading below grade level than those who are reading at or above grade level. The average reading level of struggling readers in U.S. high schools is at fourth to fifth grade level (Mastropieri, Scrugg, & Graetz, 2003). Recent national statistics show that only 34 percent of 8th graders are reading at or above a proficient level (National Center for Education Statistics [NCES], 2011) and only 30 percent of incoming high school freshmen are reading proficiently (Alliance for Excellence in Education, 2011). The poor outcome in reading is not a recent trend. For the past forty years, between the years 1971 to 2012, the reading scores of 17 year-olds as reported by the National Assessment of Education Performance have remained stagnant and only changed by one point (NCES, 2013).

Why has there been so little progress made in improving the reading outcomes even though there has been a long history of reading research and recommended intervention practices? Clearly, if only 30 percent of the incoming high school freshmen are reading proficiently, there is a persistent reading problem for adolescent readers, which needs to be addressed.

Addressing reading difficulties for upper elementary to secondary grade students is
complex when compared to addressing reading difficulties in early elementary grades. In the early years through lower elementary grades, the focus of reading is the acquisition of reading, “learning to read” (Chall, 1983). That is mainly learning about print, phonological awareness, phonics, and decoding (Chall, 1983; NICHHD, 2000). Whereas from about third to fourth grade, the focus shifts to using “reading to learn” where students are actively using their basic reading skills to gain knowledge (Chall, 1983; Chall & Jacobs, 1996; Jacobs, 2008). Therefore, for students who did not make this shift from learning to read to using reading to learn, their acquisition of vocabulary (Stanovich, 1986), general knowledge (Silver-Pacuilla, Ruedel & Mistrett, 2004; Stanovich, 1986) and writing abilities (Silver-Pacuilla et al., 2004) are also impacted. As Stanovich (1986) explains the Matthew effect in reading, those students who are poor decoders and thus are not fluent readers will read less, gain little vocabulary and knowledge, and become poorer readers, whereas good readers will continue to gain vocabulary, gain knowledge, and do well in reading. Therefore, by the time students are in secondary grades, those students who did not successfully acquire basic reading skills may be struggling to read not only because of inefficient decoding and fluency (Kamil, 2003), but also due to lack of vocabulary and prior knowledge (Cromley & Azevedo, 2007), inflexible reading strategies (Biancarosa & Snow, 2004; Cromley & Azevedo, 2007), poor reading comprehension (Biancarosa & Snow, 2004), and low motivation and low self-esteem (Graham, Pegg, & Alder, 2007). Unfortunately, there is limited opportunity for secondary students who did not learn to read to develop competence (Alexander, 2005; Allington, 2013).

As such, it is not an easy feat for secondary teachers who are not trained to teach reading to address these diverse reading challenges that students face. The challenges in providing reading instruction or interventions at the secondary level are that they are limited by the
diversity of needs of struggling readers (Deshler, Hock, & Catts, 2006; Edmonds et al., 2009; Hock, Brasseur, Deshler, Catts, & Marquis, 2005; Scammacca et al., 2007). Secondary school teachers have limited time for teaching reading due to increased accountability to cover content materials (Edmonds et al. 2009; Faggella-Luby & Deshler, 2008; Vaughn et al., 2010). In addition, even if teachers do or make the time, there is difficulty adjusting reading materials to appropriate reading levels (e.g. textbooks) or difficulty finding engaging reading materials that are at students’ independent or instructional reading levels (Deshler et al., 2006; Edmonds et al., 2009; Kamil, 2010).

Given such complexity of students’ reading issues and constraints mentioned above in teaching reading in the secondary classrooms, there is even more of a need for reading instruction/intervention that can address the barriers and change the direction of the current adolescent reading crisis. One means to address reading barriers is with the use of technology as a tool. Use of technology to teach reading is quickly expanding in today’s classroom (Silver-Pacuilla et al., 2004). Meta-analysis on technology and reading in middle grades by Moran, Ferdig, Pearson, Wardrop, and Blomeyer (2008) has shown that the technology use in improving literacy has a moderate effect size of .489. Specifically, text-to-speech (TTS) software is one technology tool that has been found to provide students with access to grade level texts and meet their diverse reading problems such as decoding, fluency, vocabulary, and reading comprehension through various features and individualization of the software (Elkind & Elkind, 2007; Edyburn 2004; Park, Roberts, Takahashi, & Stodden, 2013; Silver-Pacuilla et al., 2004).

**Text-to-Speech Software**

TTS software, sometimes referred to as ‘screen readers’ (Balajthy, 2007), ‘text reader’ (Disseldorp & Chambers, 2002), ‘scan-and-read’ (Edyburn, 2007), or ‘supported e-text’
(Anderson-Inman & Horney, 2007), is a speech synthesis that provides auditory output of electronic text or printed text that has been converted into an electronic text (e.g., Balajthy, 2005; Elkind & Elkind, 2007; Roberts, Takahashi, Park, & Stodden 2012). With TTS software, students who have difficulty reading can “listen” along while viewing the text. In schools and in the workplace, TTS software has been an assistive technology (AT) used by individuals with disabilities, especially for students with print disabilities (e.g. reading disabilities, visual impairment). As an AT, TTS software can improve the functionality of individuals with disabilities to access text, and facilitate their reading (Elkind & Elkind, 2007).

A computer-based speech synthesis technology such as TTS software has been around since the 50’s (Woodford, 2011). With the invention of an optical character recognition (OCR) system that can convert any printed font into electronic formats combined with speech synthesis technology in the 70’s (Woodford, 2011) and advancement in more naturally sounding speech synthesis, TTS software has become more available and has been integrated into different devices such as laptop computers, tablets, iPads, and cellular phones. The availability of the TTS software has led the software to be used not only by individuals with print disabilities, but also with broader audiences such as struggling readers and English language learners (Engstrom, 2005; Parr, 2012; Silver-Pacuilla & Fleischman, 2006).

**Kurzweil 3000**

The current study investigated the various tools/features of Kurzweil 3000. Kurzweil 3000 is one of the many comprehensive TTS software (e.g., WYNN, Read and Write Gold Deluxe), that is more than a simple speech synthesis. It is a high-end comprehensive product, which is suitable for “reading secondary school textbooks that have complex layouts and many illustrations and for supporting active reading strategies that enhance comprehension” (Elkind &
Elkind, 2007, p.13). The software can be customized, to meet individual readers’ needs (Elkind & Elkind, 2007). It also includes an optical character recognition (OCR) capability where scanned documents can be converted from an image file to a text file (Roberts et al., 2012). As with the most basic TTS, Kurzweil 3000’s main feature is the speech synthesis, which is to have the electronic text read aloud. However, it is unique in that it also has a “dual highlighting” feature while the text is being read (Kurzweil 3000, 2012). That is, one color highlights the unit (e.g. a sentence, a phrase, a paragraph) selected to read and another color highlights each word as it reads word by word providing a combined visual and auditory “bimodal” (Montali & Lewandowski, 1996; Silver-Pacuilla et al., 2004) presentation of text (See Figure 1).

**Figure 1.** Example display of “dual highlighting.”

Kurzweil 3000 has several other different tools to enhance the reading experience. Following are four clusters of tools investigated. More specific explanations of the tools are in Chapter 3 Methods section.

*Reading Tools.* In addition to the highlighting and reading, the Reading Tools allow the user to change the reading speed and voice of the reader. Unlike some of the earlier speech synthesis, Kurzweil 3000 v. 12 had options for high quality voices that were relatively natural sounding.

*Dictionary Tools.* Many TTS software also has a dictionary or a hyperlinked reference tools. While reading, when the reader encounters an unknown word that needs to be looked up in the dictionary, the reader can simply select the word and click the dictionary icon. A definition
window opens and the definition can also be read aloud. In Kurzweil 3000, there are a few different choices of the dictionary as well as a thesaurus, syllabication tool, and pronunciation tool to “hear a human pronounce a word” (Kurzweil 3000, 2012).

**Study Skills Tools.** Another defining feature that distinguishes a comprehensive TTS like Kurzweil 3000 from basic TTS software is the availability of the Study Skills Tools. These include annotation tools such as highlighting, circling, underlining, bubble note, and adding a sticky/text note, a footnote, or a voice note (Kurzweil 3000, 2012). An individual’s annotations can be extracted as an outline, column note, or into a new document for further use (Elkind & Elkind, 2007).

**Internet Tool.** Kurzweil 3000 allows the reader to read the Web from Internet Explorer or Mozilla Firefox (Kurzweil 3000, 2012). However, only the Reading Tools and Dictionary Tools are available while reading the Web (Elkind & Elkind 2007).

**Steppingstones: Text-to-Speech Study II**

My study further investigated the intervention effects of the Steppingstones: Text-to-Speech Phase II Study (Steppingstones Study), a large randomized controlled trial study conducted on the efficacy of the TTS software upon reading comprehension of 9th grade struggling readers (Roberts et al., 2013). The following sections summarizes the background, the method and the results of the Steppingstones Study to provide the context for my current case study.

**Background**

The Steppingstones Study was a three-year, multi-cluster, randomized controlled trial study funded by the U.S. Department of Education Steppingstones for Technology. The purpose of the study was to test the efficacy of the TTS software on reading performance. Ninth grade
struggling readers were provided with TTS software for one semester. Their performance was assessed pre-post without the aid of the TTS software. This study was conducted on Oahu, Hawai‘i in public schools. Participating teachers were randomly assigned into an intervention or a comparison group. The intervention group students used the Kurzweil 3000 v.12 to read for one semester (10 weeks) in their content area classes (e.g., social studies, science, language arts). Teachers and students were all trained to use Kurzweil 3000 by the research staff with fidelity, and students read textbooks, worksheets, and other materials from their content area classes as assigned by their teachers. Before and after the intervention, students in both groups were tested on their reading comprehension, vocabulary, and reading rate, without the use of the TTS software (unaided). They also completed pre/post surveys answering some questions about prior use of computers, attitudes towards reading, future aspirations, and use of Kurzweil 3000. The following hypotheses were tested:

H 1: Subjects in the intervention group will have statistically significantly higher unaided reading comprehension at the end of their participation when compared to subjects in the control group.

H 2: Subjects in the intervention group will have a statistically significantly higher unaided reading fluency rate at the end of their participation when compared to subjects in the control group.

H 3: Subjects in the intervention group will have statistically significantly higher unaided reading vocabulary at the end of their participation when compared to subjects in the control group.

H 4: Subjects in the intervention group will have statistically significantly better “in-school” academic performance (i.e., improved class grades and attendance) and
aspirations (i.e., improved expectations to graduate from high school & enter postsecondary education) at the end of their participation when compared to subjects in the control group.

Methods

Schools. Participating students’ data were collected from 11 different public high schools on Oahu Hawai‘i. The size of the schools ranged from small to large with approximate student enrollment ranging from 850 to 2,800 students in grades 9 through 12. Approximately 45% of students enrolled in participating schools were eligible for Free and Reduced Lunch Programs, 11.0% were receiving special education services, and approximately 7% were classified as English language learners (ELL). Within the participating schools, the most frequently spoken home languages for the ELL students was Ilokano, Chuukese and Marshallese.

Classroom. Participating students’ classes varied in size and content. The number of students ranged from 8 to 26 per class. Typical classes met two to three times a week for 35-90 minutes per session. Some classes were general education classes, some were self-contained special education classes, and others were pull out resource classes.

Participants. Participating students were 9th graders. Each semester, unique groups of students were recruited from participating content area teachers’ classes (i.e., language arts, social studies, history, and science). Students participated over the duration of one semester. Participating students also had to meet the following inclusion criteria. Students had to: (a) be in 9th grade; (b) be reading between 1.0 and 6.9 grade level equivalent (GLE) as measured by the Gates MacGinitie Reading Test (GMRT) 7/9 (MacGinitie, MacGinitie, Maria, & Dreyer, 2000) pre-intervention; and (c) have submitted both parental consent agreement and student assent forms.
**Intervention.** Prior to the intervention, students and teachers were all trained by Steppingstones Phase II Study research staff using a researcher developed Kurzweil 3000 guide (See Appendix A), which detailed the use of the TTS software. The training was one, 45-60 minutes of hands-on group training on the use of TTS software with all students in the class for the intervention group regardless of participation status so as not to single out students. Once the training was completed, a self-fidelity checklist was administered to assess student and teacher’s proficiency using the TTS software (See Appendix B). The same checklist was administered two weeks later to check their maintenance. Proficiency was met when students were able to use the software independently at a 95% mastery level.

During intervention, students were asked to use the TTS software with their class materials as assigned by their teachers for at least 30 minutes per week for approximately 10 weeks. Each student had a unique login code, which allowed for the TTS software to automatically track individual students’ usage (i.e. duration, frequency of tools use). Aside from the specified amount of minutes, there were no additional guidelines of how the TTS software should be used in the classroom: Teachers were able to determine when and how to incorporate the TTS software into their own lesson plans and instructional activities. Research staff supported teachers to convert print materials into electronic text that could be read by Kurzweil 3000 and continued to provide teachers with technical support in person, by email, and by phone for the duration of the semester.

During intervention, two research staff observed each classroom, two to three times per semester, to confirm that intervention students used the TTS software as intended.

**Results**

Results are summarized from the *Steppingstones Phase II 2014 Final Report* (Park,
Roberts, Takahashi, & Stodden 2015). The data were analyzed using the multilevel analysis to account for the nested data structure (i.e., students within teachers). The data included 477 students of 68 teachers at 11 high schools (i.e., 260 students of 36 teachers in the intervention group and 217 students of 32 teachers in the control group). On average, the intervention group used the TTS for 574 minutes for a semester; 81 minutes per week; and for 7 weeks. Students in the control group did not use the TTS software. They continued the class with business as usual.

H 1: Subjects in the intervention group will have statistically significantly higher unaided reading comprehension at the end of their participation when compared to subjects in the control group. As a result of multilevel analysis, after controlling for the pre-comprehension GLE, there was a significant difference by group in the adjusted post-comprehension ($\gamma_{01}=-.256$, $p=.099 <.10$; $\hat{Y}_q=2.535-.256(\text{Group})+.531(\text{Pre} - \text{ComprehensionGE})$)

The intervention group had higher reading comprehension scores than the control group. Students’ disability did not moderate the group-reading comprehension GLE slope ($r=.117$, $p=.669$); regardless of students’ disability status, there was a significant intervention effect on students’ reading comprehension.

H 2: Subjects in the intervention group will have a statistically significantly higher unaided reading fluency rate at the end of their participation when compared to subjects in the control group. As a result of multilevel analysis, after controlling for the pre-reading rate score, there was not a significant difference by group in the adjusted post-reading rate score ($\gamma_{01}=6.620$, $p=.485 >.10$).

H 3: Subjects in the intervention group will have statistically significantly higher unaided reading vocabulary at the end of their participation when compared to subjects in the control
group. As a result of multilevel analysis, after controlling for the pre-vocabulary GLE, there was a significant difference by group in the adjusted post-vocabulary ($\gamma_{01}=-.363$, $p=.021 <.05$; $Y_{ij} = 1.628 - 3.63\{Group\} + .713\{Pre-VocabularyGE\}$).

The intervention group had higher vocabulary scores when compared to the control group. Students’ disability did not moderate the group-vocabulary GLE slope ($\gamma = -.003$, $p=.991$); regardless of students’ disability, there was a significant intervention effect on vocabulary.

H 4: Subjects in the intervention group will have statistically significantly better “in-school” academic performance (i.e., improved class grades and attendance) and aspirations (i.e., improved expectations to graduate from high school & enter postsecondary education) at the end of their participation when compared to subjects in the control group. As a result of multilevel analysis, there was not a significant difference by group in the class grade ($\gamma_{01} = .069$, $p=.669 >.10$). As a result of multilevel analysis, there was not a significant difference by group for attendance ($\gamma_{01} = .027$, $p=.970 >.10$). As a result of multilevel analysis, after controlling for the pre-expectation level, there was not a significant difference by group in the adjusted post-expectation level ($\gamma_{01} = 0.032$, $p=.704 >.05$). As a result of multilevel analysis, after controlling for the pre-expectation level, there was not a significant difference by group in the adjusted post-expectation level ($\gamma_{01} = 0.159$, $p=.403 >.05$).

**Statement of the Problem**

The Steppingstones Study’s results have significant implications for the future use of the TTS software by the secondary students. The significant differences between the intervention and the comparison groups in reading comprehension and vocabulary gains show that using the
TTS software in content area classes is effective in improving students’ reading skills not only when students are using the TTS software, but also when they are not using the software. This implies that sustained TTS software use is more than a compensatory AT tool to support struggling readers within the secondary classroom. In fact, the results demonstrated that TTS software use has a potential remedial effect for struggling adolescent readers to improve their reading. This means that the TTS software can be a viable option as a reading intervention for some struggling readers within the secondary classrooms. This single technology tool may be able to address a wide range of reading difficulties faced by struggling adolescent readers.

The Steppingstones Study is also timely in adding to the limited literature in the area of technology and reading as this result provides evidence for the efficacy of the TTS software in improving reading vocabulary and comprehension for secondary level struggling readers. Although quite a few studies have emerged since the late 80’s into the 21st Century investigating the effects of TTS software use on students’ reading skills (e.g., Black, 2011; Disseldorp & Chambers, 2002; Elkind et al., 1996; Elkind, 1998; Farmer, Klein & Bryson, 1992; Higgins & Raskind, 1997; Lange, McPhillips, Mulhern, & Wylie, 2006; Leong, 1995; and, Raskind & Higgins, 1999), many of the studies focus on its use for students with print disabilities such as learning disabilities as well as students with Attention Deficit/Hyperactivity Disorder. Only a few studies have been conducted with secondary students who are struggling readers without identified disabilities (e.g., Disseldorp & Chambers, 2002; Lange, McPhillips, Mulhern, & Wylie, 200; Miller & Zahner, 2004; Schmitt, Hale, McCallum & Mauck, 2011). Furthermore, the results of empirical studies on the effects of TTS software in improving reading skills have been mixed (Anderson-Inman & Horney, 2007; Elkind, Cohen, & Murray, 1993). Many studies have found that for adolescent struggling readers, comprehension and reading rate significantly
improved with the use of the TTS software, but improvements were different for individuals (e.g., Dimmitt, Hodapp, Judas, Munn, & Rachow, 2006; Elkind et al., 1996; Lange, et al., 2006).

However, knowing that the TTS software intervention was effective may not be sufficient for secondary teachers to be able to implement the intervention with fidelity within their classroom. A randomized controlled study like the Steppingstones Study tells whether the intervention was effective, but it does not tell how it was effective (Hutchinson & Styles, 2010). The need to further investigate how and why the intervention was efficacious is important for three reasons: (1) With the RTI initiative and increased focus on evidence-based strategies to improve all students’ outcomes, teachers must be able to implement the intervention with fidelity, and address the diverse adolescent struggling readers’ needs in a limited time frame; (2) Only a few studies have thus far investigated which features of TTS software were used by the students that my have contributed to their reading gain (e.g., Chiang & Jacobs, 2010; Parr, 2012) and knowing the features of TTS software used may assist teachers and schools in making decisions about the types of TTS software in which to invest for struggling readers; and (3) Since the individual outcomes differed, knowing how or why it was effective will shed light on the types of struggling readers who benefited from the TTS software as compensation or remediation, both, or neither.

**Purpose**

The purpose of this embedded multiple case study was to investigate the gaps in knowledge of how the TTS intervention was effective in improving the reading comprehension by analyzing the patterns of TTS software use (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) by students who made high gains (HG), moderate gains (MG) and no or negative gains (NG) in
reading comprehension. Additionally, this study examined why the TTS pattern use may have differed by class and by students’ perceptions and attitudes towards using the TTS software. While the Steppingstones Study II findings demonstrated that students in the intervention group made significant gains in reading comprehension and vocabulary in comparison to the control group, the current study was conducted to gain in-depth understanding of the effects of TTS intervention in order for the results to be meaningful and useful for the teachers and schools in considering the TTS intervention. By knowing how and which students used the different TTS tools during the intervention, teachers and schools would be able to make an informed decision about how they should use the intervention and would also be able to know the types of TTS software to use with their struggling readers.

**Research Questions**

1. How did the students’ patterns of TTS software use (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) differ by reading gain groups?

2. Why did the students’ patterns of TTS software use (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) differ by reading gain groups?
   a. Did the teachers’ implementation impact the students’ patterns of TTS software use by reading gains?
   b. Did students’ attitudes and perceptions towards the TTS software intervention impact their patterns of TTS software use by reading gains?
Definition of Terms

Adolescent struggling reader: Adolescent student who is having difficulty with any aspect of reading regardless of whether they are receiving special education services or not. In this study, a struggling reader is considered as any student whose reading level is between 1.0 to 6.9 grade level equivalency as measured by Gates MacGinitie Reading Test (GMRT).

AT (Assistive technology): Any item, piece of equipment, or product system, whether acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain or improve the functional capabilities of individuals with disabilities (The Technology Related Assistance for Individuals with Disabilities Act of 1988).

Compensatory tool: A tool such as TTS software to work-around or bypass a deficit such as reading.

Kurzweil 3000: A type of comprehensive TTS software combined with Optical Character Recognition software.

Remediation: An approach to improve an area of deficit/weakness such as reading.

RTI (Response to Intervention): Initiated under the reauthorization of the Individuals with Disabilities Education Improvement Act (IDEA, 2004), RTI refers to a multi-tiered system of support where academically and behaviorally struggling students are provided with a series of evidence based interventions with progressing intensity.

TTS (Text-to-Speech): A speech synthesis software that provides visual and auditory input of any text on the computer screen. Comprehensive TTS refers to software that has more than a simple speech synthesis function that allows the user to change reading speed and voice, annotate within text (e.g. use highlighters, pens, and sticky notes), and look up words in the electronic dictionary and/or thesaurus.
**UDL (Universal Design for Learning):** UDL are a set of principles based on the premise of removing barriers from the curriculum that include: (1) multiple means of representation, (2) multiple means of expression; and (3) multiple means of engagement (Meyer & Rose, 2000).
CHAPTER 2
LITERATURE REVIEW

This chapter provides a background on the development of reading based on two theoretical models. These models provide a context for characterizing the literacy challenges faced by adolescents who struggle with reading. This is followed by a review of literature relevant to the study on the effectiveness of TTS software in improving students’ reading comprehension, and how and why the use of certain TTS software features has been found to be effective. This literature review extends the scope of the initial Steppingstones Study to include consideration of TTS software, not only as an AT tool but also as an educational scaffold (Marino, 2009) and intervention tool within a Universal Design for Learning (UDL) framework (Rose & Meyer, 2000).

Development of Reading

If educators understood the nature of changes that should occur in readers as they progress toward competence, and if educators had some idea of the problems that might arise during that journey, then they could better formulate interventions or craft educational materials that might circumvent problems or ameliorate their effects (Alexander, 2005, p.5).

Two models on development of reading are presented here: (1) Chall’s Reading Stages (1983), and (2) a Lifespan Developmental Perspective on Reading (Alexander, 2005). Both of these models provide context in understanding the reading expectations, demands and skills required by adolescents. Chall and Alexander view reading acquisition as a continuum that unfolds over time. This way of viewing reading helps in understanding adolescent needs that differ from those of young readers (Alexander, 2005; Jacobs, 2008). It also aids in reviewing the...
extent the TTS software intervention can address the diverse and changing needs of the adolescent readers. This view of reading progressing along a continuum also provides a foundation upon which to determine whether the TTS software is a viable intervention for the diverse and changing needs of adolescent readers.

**Chall’s Stages**

There are a number of reading theories and models which describe the development and process of reading (e.g., Adams, 1994; Chall, 1983; Ehri, 1995; Gough & Tunmer, 1986; Gough, Hoover & Peterson, 1996; Kintsch, 1998), but in general, most reading theorists and researchers agree that reading is a complex task that requires coordination of multiple skills (e.g., Anderson, 1985; Edmonds et al., 2009; Hock et al, 2009; Kintsch, 1998; Lesaux & Kieffer, 2010).

According to Chall’s Stages of Reading (1983), there are six stages to learning to read.

**Stage 0.** Stage 0 is Prereading or “pseudo reading” (0-6 years old). At this stage, children are not quite reading yet, but they are getting ready to read or pretending to read. This stage is about looking at letters and learning about orientation of books and images of print. Although they are not reading words, they are building vocabulary knowledge and acquiring understanding for the basic conventions of reading as well as gaining an appreciation for reading. This stage is fostered by an adult or someone older showing books and other items related to reading.

**Stage 1.** Stage 1 is Decoding (6-7 years old). Children begin to make association with letters and sounds and practice beginning reading skills during this stage. They are able to “sound out” syllables and words. They also are able to read some sight and familiar words that they see often. This skill is acquired through direct instruction of phonics and reading beginning
reader books. At this stage, children’s listening comprehension is much greater; they can understand 4,000 words when they hear, but may only be able to read 600 words.

**Stage 2.** Following Stage 1 is Stage 2, Confirmation (7-8 years old). During this stage, children are still learning to decode, but they are becoming more competent in decoding and the words are “ungluing” from the page. The children are developing fluency skill and increasing vocabulary. This stage is fostered with instruction in advanced decoding, wide reading, vocabulary instruction and interest building. Listening is still predominant, but children at the end of this stage can read about 3,000 words and understand 9,000 from listening.

**Stage 3.** This is referred to as Reading for Learning the New (9-15 years old). This is the transition stage where students are no longer just learning to read, but using reading to learn “to gain new knowledge, to experience new feelings, to learn new attitudes, generally from one viewpoint” (Chall, 1983). This shift often happens between third to fourth grades. Because not everyone makes this shift, but the school demand and expectation also shifts at the same time, the reading gap between those who are able to acquire prerequisite skills and those who have not begins to widen (Chall, 1996). At this stage, listening and reading skills are used equally in acquiring information, and for some, reading becomes more efficient.

**Stage 4.** Stage 4 is Multiple Viewpoints (15-17 years old). By this stage, adolescents are expected to use reading to understand author’s intent and interact with the text for comprehension. Adolescents are reading both narrative and expository texts. To foster development of multiple viewpoints, wide reading from a broad range of materials are encouraged. By this stage, reading comprehension is better than listening comprehension especially for complex materials.
Stage 5. The final stage is Construction and Reconstruction (18 years and older) stage. During this stage, the students are able to use reading for personal or professional purposes. Reading is efficient and often has a purpose. Readers synthesize information and knowledge to create new knowledge. For those who have reached this stage, reading is much more efficient than listening.

Lifespan Developmental Model

Complementary to Chall’s Stages (1983), the Lifespan Developmental Model (Alexander, 2005) has stages, but unlike Chall, each stage is not necessarily bound by age or grade. There are three main stages across the lifespan: acclimation, competence and proficiency/expertise. Each stage is also characterized by the development of knowledge, interest in reading and strategy processing (see Table 1).

Table 1

*Underlying Constructs of Lifespan Development Model*

<table>
<thead>
<tr>
<th>Three Defining Characteristics</th>
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<tbody>
<tr>
<td>1. Reader’s knowledge of language and knowledge of content domains are critical forces in developing competence</td>
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<tr>
<td>2. Reader’s personal interest in reading becomes a driving force in their development as competence is achieved</td>
</tr>
<tr>
<td>3. Lifespan development involves systematic changes in readers’ strategic processing</td>
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</table>

*Note.* Characteristics defined by Alexander (2005).

Knowledge. Alexander (2005) describes two forms of knowledge: domain knowledge and topic knowledge. Domain knowledge is “the breadth of one’s knowledge” (p. 7) about reading and topic knowledge, is knowledge about specific topics such as dinosaurs, history, and cell reproduction. These two forms of knowledge are interconnected. The more one knows how
to read and learns about reading, the more they will read and be exposed to various topics. Thus, knowledge is a significant predictor of developing reading competence (Alexander, Kulikowich, & Schulze, 1994).

**Interest.** Interest is found to be a powerful indicator of learning (Hidi, 1990; Hidi & Renninger, 2006) and recall of information in reading (Schieffele & Krapp, 1996). Similar to knowledge, Alexander (2005) in his model, describes the two forms of interests: individual and situational. Individual interest refers to personal preference (Alexander, 2005; Hidi, 1990) and situational interest is elicited by something external, like something that one saw or heard (Hidi, 1990; Hidi & Renninger, 2006).

**Strategic processing.** Strategic processing impacts reading comprehension (Magliano, Trabasso, Graesser, 1999) and learning in general (Nolen, 1988). There are two forms of strategic processing in Alexander (2005)’s Lifespan Model: surface-level and deep-processing strategies. According to Alexander (2005), surface-level strategies are strategies such as rereading, skipping words that are unfamiliar, and adjusting rate. Deep-processing on the other hand is comparison of various texts, questioning the source, making connections to prior knowledge and monitoring comprehension (Alexander, 2005; Entwistle, 1996)

**Three Stages**

**Acclimation.** This stage is similar to Chall’s Stages 0-2 where individuals are beginning to learn about reading. At this stage, Alexander (2005) explains that the readers may not know in depth about the concept of reading. Both domain knowledge and topic knowledge are limited at this stage. At this stage, individual’s reading is driven much more by situational interest than individual interest. Individual interest is low as the readers have not been exposed to much. For instance, my three-year old daughter’s choices of books to read during bedtime are not
necessarily based on a specific genre, author, or field, but rather what “looks” appealing or it may be on a topic that she encountered at her preschool. Finally, at this stage, individuals may only utilize surface-level reading strategies rather than deep-processing strategies. The readers at this stage may know how to sound out words, pause and think if they misread a word, or know to reread.

**Competence.** This is a transformation stage. In Chall’s (1983) stages of reading, this falls under Stages 3-4. At this stage, individual readers have gained more knowledge and therefore, they are able to utilize strategies better. Alexander (2005) states that at this stage, readers have begun to develop individual interests and have more intrinsic motivation to seek information from reading. The major transition, however, is in the strategic processing. Readers demonstrate deep-processing strategies rather than surface-level strategies. Early stage in the Competence stage is similar to Chall’s Stage 3 where readers are developing metacognitive strategies to monitor and adjust their reading (Jacobs, 2008). By the late Competence stage, Chall’s Stage 4, readers are able to analyze and synthesize information by questioning the sources of information and comparing the texts (Alexander, 2005; Jacobs, 2008).

**Proficiency/expertise.** The final stage is where the reader has gained knowledge in reading, is invested in their domain of their interest, and is able to utilize effective and efficient strategies (Alexander, 2005; Alvarez & Armstrong, 2009). Readers at this stage have more mental space that they can devote to questioning and thinking critically about their readings. As in Chall’s Stage 5, “they have the skills and self-awareness to be independent readers of multiple disciplines” (Jacobs, 2008, p.15).

**Struggling Adolescent Readers**

Based on the two models of reading development, by adolescence, an individual may
become a competent reader with these skills and qualities: (a) able to decode, (b) able to read fluently, (c) possesses a sufficient vocabulary, (d) has gained knowledge about reading and knowledge on various topics, (e) is personally interested in and motivated to read, (f) is able to take multiple viewpoints, and (g) uses various strategies to make meaning from what they read.

Unfortunately, many adolescent readers do not reach this competence by high school for many reasons (Curtis & Longo, 1999; Hock et al., 2009; Levine, 1994; Scammacca et al., 2007; Torgesen et al., 2007). Boardman, Roberts, Vaughn, Wexler, Murray, and Kosanovich (2008) reported that one in four students in grades four to 12 in 2005 were identified as struggling readers. Biancarosa and Snow (2006) reported up to 70% of students struggle with reading. The students who are identified as “struggling” were heterogenous and have diverse needs (Brasseur-Hock, Hock, Kieffer, Biancarosa, & Deshler, 2011). Brasseur-Hock et al. (2011) tested 319 students who were ninth graders in an urban setting on their reading comprehension and other component skills: vocabulary, listening comprehension, word and text-level accuracy and fluency. The results of the study found that there were subgroups of students with below average reading comprehension that had specific weakness in listening comprehension, specific weakness in reading comprehension, struggled with fluency, and who had global weaknesses. They concluded that there was no single underlying source for poor comprehension. Hock et al., (2009) studied 345 adolescent struggling readers and identified their reading component skills. In their study, they found that 61% of variance in reading skills was due to word level problems.

These students, for whatever reason struggle to move into the competence stage of reading and acquire limited reading skills. They also read less, which negates opportunities to gain necessary background knowledge and vocabulary required for comprehension (Engstrom, 2005). There are also those who learn to decode, but they may not have acquired sufficient
background knowledge, vocabulary, or metacognitive awareness to regulate their understanding while reading (Alvarez et al., 2009; Paris & Myers, 1981). Additionally, students’ acquisition at different stages may also be hampered by learning disabilities, English as a second language, or underexposure (Salinger, 2012). Finally, some of them may simply lack motivation to succeed at reading due to early reading failures (Guthrie, 2008).

In sum, Table 2 is a list of underlying reasons for adolescent reading difficulties compiled from various literatures (Alvarez et al., 2009; Biancarosa & Snow, 2006; Braseur-Hock et al., 2011; Cromley & Azevedo, 2007; Hock et al., 2009; Lesaux & Kiefer, 2010; Levine, 1994; Scammacca et al., 2013). The table is not a comprehensive list, and the items are not mutually exclusive; adolescent readers can have any combinations of challenges listed.

Table 2

*List of Underlying Factors of Reading Difficulty*

<table>
<thead>
<tr>
<th>Example Factors</th>
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<tbody>
<tr>
<td>1. Lack of exposure to reading</td>
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<td>2. Poor phonological awareness</td>
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<td>3. Ineffective decoding</td>
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<tr>
<td>4. Poor fluency</td>
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<tr>
<td>5. Poor vocabulary</td>
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<tr>
<td>6. Poor comprehension</td>
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<tr>
<td>7. Limited prior knowledge</td>
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<tr>
<td>8. Inflexible/inefficient use of reading strategies</td>
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<tr>
<td>9. Difficulty with monitoring understanding</td>
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<tr>
<td>10. Low application/ generalization</td>
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<tr>
<td>11. Reading avoidance / lack of reading self-efficacy</td>
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<tr>
<td>12. Lack of motivation</td>
</tr>
<tr>
<td>13. Exposure to limited/ineffective reading instruction</td>
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</table>
Use of Text-to-Speech Software as Reading Intervention

As described previously, unlike the young readers who are just beginning to read, the reasons why adolescent readers struggle vary greatly. Effective reading must be fast (i.e., fluent) and selective, and is dependent on knowledge, interest and strategic processing (Alexander, 2005). In fact, there has been much research supporting the importance of reading fluency in relation to reading comprehension (Altwerger, Jordan, & Shelton, 2007; Breznitz, 2006; Winn, Skinner, Oliver, Hale & Ziegler, 2006). Reading fluently means accurate reading of connected text at a conversational rate (180 wpm) or faster (Torgesen & Hudson, 2006). When one is able to decode words fluently, more room is left in one’s working memory for constructing meaning from the text. Furthermore, the faster the reading rate, students are exposed to more vocabulary, text and information (Mellard & Patterson, 2008; Winn et al., 2006). Winn et al. (2006) speculate that an increased reading rate will also have a positive impact on the motivation of students because they experience less fatigue while reading.

Yet, the expectations within the secondary classrooms continue to become challenging with complex texts, leaving these students further behind without effective interventions (Edmonds et al., 2009; Slavin, Cheung, Groff, & Lake, 2008). In high school, there is limited time for instruction (Edmonds et al., 2009; Faggella-Luby & Deshler, 2008; Slavin et al., 2008). Content area teachers are faced with accountability and they are not trained to teach “reading” (Allington, 2013; Heller, n.d.). Moreover, several research studies show that textbooks used in high schools are needlessly complex (Mastropieri, Scruggs, & Graetz, 2003; Slavin et al., 2008). Thus, students in secondary grades face multiple challenges in becoming successful readers and teachers need to address these varied challenges in implementing reading instruction and intervention.
Efficacy of the TTS Software

Although TTS software is not a panacea for all underlying issues in reading as shown in Table 2, several studies have demonstrated its efficacy in improving phonemic awareness, decoding, vocabulary, reading fluency comprehension, metacognition and motivation (e.g., Disseldorp & Chambers, 2002; Elkind, 1998; Forgrave, 2002; Higgins & Raskind, 2005; Lundberg, 1995; Manset-Williamson et al., 2008; Raskind & Higgins, 1999). TTS software use has also received attention for its individualization and immediate visual/auditory feedback relieving students of having to use mental energy for decoding (Farmer, Klein, & Bryson, 1992). Fasting and Halaas-Lyster (2005) also found that the TTS software’s highlighting assisted struggling reader to ‘keep-on-track’ without losing their spot.

Therefore, through the use of the TTS software, it is possible for adolescent learners who are struggling readers to experience fluent reading by (1) bypassing the need to decode, (2) eliminating accidentally skipping words or a line with the highlighting, and (3) being able to hear the pronunciation of unknown words. Conceptually, this should leave mental space for students to be able to focus on the context of what they are reading so that they can engage in reading. It may also provide the opportunity for students to move from the Acclimation Stage into the Competence Stage (Alexander, 2005).

Studies have repeatedly shown that individuals’ vocabulary is a fundamental factor in their ability to comprehend what they read (Rott, 2004; Rupley, 2009). Reading at length and widely is a valuable way to increase vocabulary. With an increase in fluency and the amount of time spent reading when using TTS, individuals who struggle to read will be exposed to more vocabulary. The more exposure learners have to a word, the more likely it is that the learners will be able to define, comprehend, and remember it (Cunningham, 2005). This also impacts
reading comprehension because not knowing the meaning of words as used in a given text results in decreased comprehension. Comprehending any passage requires understanding the meaning of the important content-bearing words, but often the meaning of those key words depends on an interaction of word meanings and their meaning within a specific passage (Baumann, Hoffman, Moon & Duffy-Hester, 1998). The auditory presentation of text when using TTS software may compensate for lack of vocabulary and thus improve reading comprehension.

This next section summarizes some of the literature on efficacy of the TTS software, particularly on reading comprehension of adolescent struggling readers. Following the literature on efficacy is a review of literature on how the TTS software tools are used within those studies to draw conclusions on whether there are any trends on specific features of TTS software use.

**Studies prior to IDEA 2004.** Several early empirical studies have focused on investigating the efficacy of TTS software on reading comprehension outcomes using the TTS software (e.g., Disseldorp & Chambers, 2002; Elkind, et al., 1996; Elkind et al., 1993; Farmer, et al., 1992; Higgins & Raskind, 2000; Leong, 1992, 1995; Lundberg, 1995; Lundberg & Olofsson, 1993; McArthur & Haynes, 1995; Montali & Lewandowski, 1996; Raskind & Higgins, 1999; Steele, Lewandowski, & Rusling, 1996; Wise, Ring & Olson, 2000).

Most of these studies, however, were conducted with children or adults and not with secondary students. Three studies are included here that targeted secondary students.

Farmer et al. (1992) investigated whether the TTS software (DECTalk) would lead to improved word recognition and comprehension of adolescent students with severe reading disabilities. Fourteen students ranging in ages from 13 to 18 years old participated in the study. They were all reading at least two years below grade level with an average reading grade level equivalency of 4.65. Using the DECTalk, students read on average 25.5 stories of varying levels
for 20-30 minutes, for over seven weeks. The DECTalk did not read back the whole story to the students. Students were able to hear the words that they “tagged” using the mouse. Students were asked to tag the words that they did not know. These stories were provided to students with the DECTalk on and off condition in an alternative format. After reading the story, students were tested on their comprehension. Approximately once a week, the students were tested on the recognition of the tagged words as well as other preselected words from the stories. Results of the study showed no difference in the mean percentage of comprehension questions answered correctly between the DECTalk on and off conditions. In addition, there was no improvement in word recognition.

Although Farmer et al.’s (1992) study results did not demonstrate the efficacy of the DECTalk use with high school students who were reading two or more grade levels below, there were several conditions that were interesting to note. The stories were only slightly above their reading level and may not have been interesting enough. In addition, the students seemed to have under utilized the tagging to “hear” enough words. On average, students only tagged 3.51 words with DECTalk on and 2.32 words with DECTalk off. Therefore, over the seven weeks, students only were exposed to an average of 75 “new/challenging” words. Farmer et al. (1992) noted that in fact only one student used the tagging consistently. Moreover, when reviewing the actual time spent on the DECTalk over the seven weeks, students spent only 37 minutes to 177 minutes total.

Elkind et al. (1993) used computer speech synthesis called Bookwise with 28 middle school students with dyslexia in fifth to eighth grade. Much like Kurzweil 3000, Bookwise is a PC based program that provides an auditory and visual output of the text. When the text is being read aloud, the text is highlighted. The reader can adjust the speed and the voice. There is also a
dictionary feature that provides the meaning, syllabication and pronunciation of the words. Reading comprehension scores tested using Gates MacGinitie Reading Test (GMRT) ranged from grade level equivalency of two to 11. Participants were in two classes. Students in one class used Bookwise one semester and another class used the Bookwise the following semester. Students used the software for 30 minutes, four times a week for a semester totaling 20-25 hours of use. The results of the study revealed that students’ reading comprehension on Gray Oral Reading Test Revised (GORT-R) improved significantly while using Bookwise. GORT-R was administered in an unconventional way where students read aloud the first time and listened to the passage the second time using Bookwise. Thus, the study showed that Bookwise had a compensatory effect. However, there was individual variability. Those who made gains made 1.0 GLE to 3.0 GLE gains. Other students remained the same and some regressed. In comparison, when GORT-R was administered in the standard way and GMRT was used in the standard way without Bookwise (unaided), the study did not show an overall remediation effect. That is, students’ gains in scores on GORT-R and GMRT could not be attributed to the Bookwise intervention. Finally, interview with the students revealed that there were some class differences in attitudes and perceptions about Bookwise. As a class, one class was more positive than another class. When asked what was most helpful, students liked “reading hard words and reading faster” (p.256). In addition, it is important to note that there were a couple of students who did not like using the software. They said that they had difficulty attending to the reading simultaneously with visual and auditory feedback.

McArthur and Haynes (1995) used a software called Student Assistant from Learning from Text (SALT) to create a hypermedia version of a science textbook for students in grades nine and 10. SALT includes features such as TTS, on-line glossary, highlighting, text extraction,
as well as metacognitive strategies for reading comprehension such as summarizing, self-questioning, and activating prior knowledge. In addition, SALT also includes teacher made content related support such as meaning of key vocabularies. Ten students with learning disabilities participated in the study. A repeated measures design was used where the biology text was introduced as a basic electronic text and as an electronic text with the entire enhancement. Students were trained on SALT for 20-30 minutes before use. Over two to three days, students read passages and answered questions in both conditions. Results of the study showed that of the 10 students, nine students performed better on the enhanced version using SALT. In the follow up interview, students were asked what they liked about the software. Students felt that the program helped them to learn, but two students preferred learning from a teacher than the computer and one student preferred the basic unenhanced version as it was simpler and did not require much thinking. With regard to specific features, students gave high ratings to study skills type tools such as highlighting main ideas, linking questions to the text, linking graphics to the text and the notebook. The ratings were relatively lower for typical TTS software features such as speech synthesis, the glossary, and text extraction. From the open-ended questions, some students commented that the speech was difficult to understand or follow whereas others said it was the most helpful feature. Two students who used the speech synthesis were students who had difficulty reading fluently. Three students did not use the speech synthesis at all.

Studies after IDEA 2004. There has been much advancement of technology and use of educational technology within the classroom since reauthorization of IDEA 2004. Thus, I conducted a systematic review of literature since IDEA 2004 to further examine the empirical research on the effects of the TTS software on reading comprehension of students who are
struggling readers in secondary school. From the search, seven empirical studies were selected based on the inclusion and exclusion criteria (see Table 3). All seven studies used the TTS software with adolescents identified as struggling reader or with LD. The full synthesis report is in Appendix C. In the current review, all of the studies except the one by Izzo et al. (2009) used a TTS software that have tools and features that were more than a simple speech synthesis.

Table 3

Empirical Studies on the Efficacy of TTS From 2004 to 2011

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<thead>
<tr>
<th>Reference of Selected Studies</th>
<th>Description</th>
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However, very few studies made clear what features and tools of comprehensive TTS were used aside from the speech synthesis. Six of the studies utilized the highlighting feature along with the speech synthesis. This bimodal aspect of a comprehensive TTS (i.e. visual tracking of the text with a highlighter and hearing of the words through speech synthesis simultaneously) is consistent with the past studies which have shown to improve word recognition and reading comprehension (Disseldorp & Chambers, 2002; Elkind et al., 1996; Elkind et al., 1993; Hecker, Burns, Katz & Elkind, 2002; Higgins & Raskind, 1997; Leong, 1995; Shany & Biemiller, 1995).

Two studies that were implemented within a classroom setting are further examined here from the synthesis. Miller and Zahner (2004) investigated how TTS software, Kurzweil 3000 could improve middle school students’ reading in science class. Thirty 7th grade students from three Life Science classes participated in their study. Half of the students were diagnosed as having learning disabilities. During their class, students used Kurzweil 3000 in one area of the classroom for taking tests, completing workbook pages and for preparing study guides. Students used the speech synthesis feature with the dual highlighting and were allowed to type their answers onto the scanned documents. Kaufman Test of Educational Achievement (KTEA) Brief was used pre-post to measure changes in reading outcome. No statistical test results were reported, but the change in gains for the intervention students was reported to be non significant. From their observation, Miller and Zahner (2004) reported that after two weeks, some students stopped listening to the speech synthesis and just completed the question on the computer by reading the question on their own. Only four students continued to use the TTS software as intended. From the individual interviews and focus groups, students’ attitudes towards intervention and likes and dislikes of the software were asked. When asked about the speech
synthesis, 91% said they were comfortable with the reading; one student said it slowed her down; and one student did not enjoy the tool. When asked about what they liked, students liked typing the answers and using the highlighter to answer multiple-choice questions. They disliked that the computer read slower than they did and did not like using the track pad on the computers.

The results of the study did not demonstrate the efficacy of the TTS software in improving comprehension. However, a couple interesting observations should be noted. Although not specifically stated by Miller and Zahner (2004), those students whose reading rate was faster, found the TTS software unhelpful. This finding is similar to others who found that better readers benefited less from TTS software (e.g., Disseldorp & Chambers, 2002; Lundberg, 1995). Participating students also were not always focused and used the software as intended; they used only the features that they felt were beneficial to them. It is unclear, however, what features students continued to use and which students used the different tools. Such information would have provided for whom the TTS software was most helpful.

Izzo et al. (2009) conducted a study to examine the effects of TTS software called CLiCk, Speak TTS screen readers software on reading comprehension and academic achievement of high school students with disabilities. CLiCk, Speak was used with EnvisionIT curriculum in the English resource room. Seven students who were reading below grade level based on AIMSweb Maze reading test participated in the study. CLiCk,Speak was a simple TTS and for the study, students were allowed to use the speech synthesis and adjust the rate of the speech. Students took the chapter quizzes and unit tests using the TTS and without the TTS. The results of the study showed that students improved their reading comprehension on the unit quizzes and tests when they used the speech synthesis. For the unit quizzes, two students’ scores declined when using TTS. However, for the unit tests, all students improved with TTS with an
effect size of 1.3. These students were all struggling readers who had been identified as benchmark, strategic, or intensive readers. Regardless of their reading status, students made gains.

This study only had one feature, which is the speech synthesis without any highlighting. There was no information about whether students changed the speed of the reading. Although it did not investigate any other features, it is an important study as it supports the effectiveness of the auditory input for the struggling readers.

Summary

In reviewing the literature on the effects of TTS software use by adolescent struggling readers, studies prior to IDEA 2004 and post IDEA 2004 had similar outcomes. Key findings on the efficacy of TTS software over the past twenty years are summarized below.

- Studies showed that reading comprehension improved while using TTS software (compensatory effect).
- Studies showed that reading comprehension improved when not using the TTS software (remedial effect).
- Studies showed that the reading comprehension decreased for some adolescents with the use of the TTS software.
- Studies showed that the reading rate improved with the use of TTS software.
- Studies showed that vocabulary improved when not using the TTS software.
- Studies showed that students who had difficulty with auditory skills or simultaneous visual-auditory input did not benefit from the TTS software use.
- Studies showed that readers who had lower unaided reading skills benefited more.
- There were no differences in benefits of TTS software use for adolescent struggling
readers with disabilities and without disabilities.

- In general, students reported positive perceptions about the use of the TTS software.

**Beyond Efficacy**

In conducting the review of literature, very few empirical studies were found on the use of TTS software with adolescent struggling readers since 2004. This is surprising as there are more different types and choices of TTS software now when compared to the past. Perhaps the TTS software are now simply becoming part of a normal educational tool within the classroom, and there is a shift in viewing TTS software only as an AT. In fact, the studies since 2004 on TTS software had less focus on whether the TTS software was considered as a compensatory tool or a remedial tool. Nonetheless, literature revealed only limited information on how the individual participants used the TTS software or what types of tools they had accessed while using the software. Not only is such information important to demonstrate how TTS software can be used to have a consistently positive impact on improving reading skills (Anderson-Inman & Horney, 2007), but also it is helpful to the teachers in making the decision about the TTS software intervention use. That is, with an expanding choices of technology, validating which TTS intervention is most effective for which students in which situations becomes extremely important (Silver-Pacuilla et al., 2004). Marino (2009) also contends that the effectiveness of technology-based tools depend on “the individual students, the classroom context (e.g., grade level or content area), the quality and types of tools, and the extent to which students use the tools” (Marino, 2009, p.89). Therefore, more studies need to focus on the actual use of the TTS software and its associated features now that its efficacy has been established.

Three additional studies are introduced here that investigated specific feature/tools use to understand how TTS or educational tools like TTS are used by adolescent readers. These studies
were not included in the previous literature review but are worth noting to provide further context for my study.

Parr (2012) conducted an ethnographic inquiry to closely examine the use of TTS software (Kurzweil 3000) as a “part of comprehensive reading approach” (p.1426). The study was conducted with 28 students in fifth grade for eight months in an authentic classroom environment. Students used Kurzweil 3000 for approximately twice a week for three hours each session. During this time, students made their own choices for TTS software use rather than the teachers. From her observations and interviews, Parr identified three types of student users: (a) a confident reader; (b) a contextual chooser; and (c) an enabled user. A confident reader is someone who has good decoding skill and is a fluent reader with good comprehension. This individual knows about reading and is motivated to read. Thus, confident readers in her study did not utilize the TTS software much as it was not beneficial and it interfered with their own reading processes. A contextual chooser is one that uses TTS software as a motivator and only used TTS software when needed. This type of student typically has low motivation and self-efficacy, but does not necessarily have issues with decoding or fluency. For this type of student, TTS software becomes a choice and may enhance their interest and focus when reading. In her study, Parr described a student who would read different books and use the TTS software as a contextual chooser. Finally, Parr described the “enabled user.” An enabled user is a student who has learned how to use the TTS software well and knows how it benefits them. This type of student may be a slower decoder with a low level of fluency. For an enabled user, the TTS software is an AT to provide the support needed.

Similar to the Steppingstones Study, Parr’s (2012) study took place in a natural classroom environment. What is unique is that the students were given autonomy with choice in using the
TTS software and the software was considered as one of the many tools available to support their reading time. However, in her study, she did not provide a specific description of how the training was implemented and whether all the tools were introduced and reinforced throughout the study. In addition, although Parr (2012) identified the three types of learners based on their use, there is no description about which type of students used the TTS tools/features, how long the students actually used the software over eight months, nor whether the use of TTS software actually improved the students’ reading outcomes or class grades.

Marino (2009) examined the types of cognitive tools adolescent struggling readers used while using a technology-based science curriculum. Although his study did not specifically have TTS software or features of the TTS software, the study is relevant because he examined the relationship between students’ reading ability and the frequency of certain technology tools that supported science text comprehension. Participants were 1,153 students from four schools ranging in grades from sixth to eighth. These students were further grouped based on their reading scores as: (1) severe reading difficulties (n=126); (2) poor readers (n=205); and (3) proficient readers (n=822). At each of the schools, teachers were trained to implement a special technology based astronomy curriculum called Alien Rescue. Embedded within this on-line curriculum were various tools to support individual learning. These tools provided additional information about a topic or tutorials. There were also tools that provided background information, graphic organizers, and illustration. The curriculum was implemented for four weeks and each student had a computer to access the curriculum. During the implementation, students’ specific tool use was automatically recorded by the program. The results of the study showed that use of cognitive tools improved the post-test outcomes, but use of tools that supported out-of-reach activities had a negative impact on the post-test scores. That is, the more
out-of-reach activities tools were used, the students’ post-test scores decreased. Another finding was that there were no differences in the frequency of the tools use or the post-test scores between the severe and poor reader groups. However, there were statistically significant differences between the proficient readers and the severe and poor reader combined group. The main difference was that proficient readers used the technology-based tools more than the non-proficient readers. In fact, the non-proficient readers did not use the technology-based tools even though their use would have been more beneficial than the proficient readers.

Marino’s (2009) study gives insight into how students’ use of certain tools can impact the comprehension outcomes. Not all tools use were helpful in the overall achievement. In addition, there were differences in tools use by proficient and non-proficient readers. This may be the case as the proficient readers were able to monitor their reading better than the non-proficient readers (Alexander, 2005).

Dolan, Hall, Banerjee, Chun and Strangman (2005) conducted a pilot study to investigate the effectiveness of the use of TTS software as a standardized test accommodation. This study also investigated what aspects of the TTS software were effective in taking the test with TTS. Nine students with LD in 11th and 12th grade participated in the study. Students were administered US History and Civics tests in two ways: on computer using TTS and using paper-and-pencil format. The order of administration was counterbalanced across four groups. All students were trained on how to use the computer based TTS. Cast eReader™ was used as the TTS software. Cast eReader™ is a basic speech synthesis with options for synchronized highlighting of words. Students were allowed to use the TTS to listen to the test passages as well as questions and answer choices. The results of the study showed that students performed better using the TTS than paper-and-pencil format though not significant. However, when their
performance was compared for longer reading passages, the score difference with and without
the TTS was statistically significant; students scored 22 percentage points higher using the TTS
software. In further examining the student profiles, students who were low average readers
performed better on the longer passages when using the TTS software. This was not examined
for short passages. With regard to their attitudes, all students reported that TTS was easier to use
and understand than the paper-and-pencil format. Ninety percent of the students reported that
they used the TTS software for reading the passages, but only 40% said they used it a lot for
reading the questions and answers. Twenty percent of the students did not use the TTS for the
questions and answers. Individual interviews revealed that students liked having control and
thought that the TTS software helped improve their testing outcomes. Some of them did not like
the voice.

Dolan et al. (2005) investigated the TTS software in testing accommodation. The study
revealed that students benefited more when using it with longer passages. In fact, some students
did not use the TTS for short passages. It is unknown whether the students who used the TTS
software for both passages and questions and answers scored better than those who did not.
Also, even though Dolan et al. (2005) tried to investigate the individual usage, they did not
report whether the students used the options of using the visual highlight or just the auditory
feedback.

**TTS within UDL Framework**

The three studies are examples of how TTS software or similar educational tools are used
and how students benefit in using such tools. Interestingly, these studies all used UDL
framework (Meyer & Rose, 2000) to view TTS software rather than focusing on the TTS
software as AT. UDL principles are based on the premise of removing barriers from the
curriculum (Rose, Meyer & Hitchcock, 2005). UDL utilizes technologies to create “a flexible curriculum, which in standards-based settings includes instructional goals, methods, assessments, and materials” (Meo, 2008, p. 21). The three core principles of UDL include: (1) multiple means of representation, (2) multiple means of expression; and (3) multiple means of engagement (Meyer & Rose, 2000). Multiple means of representation is for students to be provided with more than one way to learn particular information, task or problem (e.g. reading from print text and reading with the TTS software). Multiple means of expression allows for students to demonstrate their skills using different modalities and forms (e.g., oral presentation, writing, video-making). Multiple means of engagement “recognizes the centrality of motivation in learning and the individual differences that underlie motivation and engagement” (Meyer and Rose, 2000, p. 10). For some students, reading from a computer may be more engaging than reading from a printed textbook.

With more students with disabilities participating in the general education classrooms in an inclusive setting, and in considering the many at risk undiagnosed struggling adolescent readers, it may be time to consider the TTS within a UDL framework first rather than as an AT. With the potential of the TTS software to improve the reading outcome, the software should be available to the broadest audience rather than only for the select few who have a diagnosed disability. However, in order to effectively provide such option of using the TTS software intervention to all learners in the secondary classroom, examining how these struggling adolescent readers use the various TTS software tools is an important topic of exploration.
CHAPTER 3

METHODOLOGY

The current study used existing data from the Steppingstones Study, a large experimental study conducted to investigate the effectiveness of the TTS software intervention in improving the reading outcomes (rate, vocabulary, and comprehension) of ninth grade struggling readers. I was involved in the Steppingstones Study as one of the researchers and coordinated the project during its implementation. The Steppingstones Study employed a concurrent nested mixed methods design (Creswell, Plano Clark, Gutmann, & Hanson, 2003) also known as an embedded design (Creswell, 2009; Creswell, Fetters, & Plano Clark 2005). In this design, both quantitative and qualitative data are typically collected at the same time, but there is a predominant design. The predominant design for the Steppingstones Study was quantitative - a multi-cluster randomized controlled trial – that included 477 students of 68 teachers at 11 high schools on O‘ahu Hawai‘i.

Concurrent nested mixed methods design, such as the one used in the Steppingstones Study, is useful in answering secondary research questions for the same outcome (i.e. reading) and also for gaining broader perspectives (Creswell et al., 2003). Therefore, extending upon the Steppingstones Study findings and utilizing the data collected from the Steppingstones Study, I investigated how the TTS intervention was effective for a subgroup of students. The main outcomes examined in the Steppingstones Study were the participants’ improvement in reading vocabulary, reading rate, comprehension as well as in-school academic performance. The Steppingstones Study results showed that there were statistically significant differences between the intervention and the comparison group in reading comprehension and vocabulary gains.
Students in the intervention groups had greater gains in both reading comprehension and vocabulary after one semester than the comparison group students.

Knowing that the TTS software intervention was effective and in conceptualizing my current study, I conducted preliminary analyses from the data collected. First, I examined whether there was a moderating effect for the overall reading comprehension outcomes for participants with disability and/or those who were English Language Learners (ELL). These moderators were examined because if the TTS software intervention were effective for a particular group of students, then the study on how the TTS software was effective would be more meaningful to examine the group who benefited the most from the intervention. The results of ANCOVA showed that the effectiveness of the TTS software use was the same regardless of participants’ disability status or ELL status. In other words, the TTS software intervention was equally effective for all participants regardless of their disability status or ELL status. Therefore, for this study, I made the decision to examine all intervention students’ data regardless of their disability or ELL status.

Secondly, I examined the intervention group students’ pre-post reading comprehension data to determine whether there were meaningful groupings based on reading comprehension gains. Three distinct groups emerged from conducting descriptive statistics of the intervention students’ reading outcome data - high gain group (HG), moderate gain group (MG), and no or negative gain group (NG). Thus, these reading gain groups shaped my research questions.

In focusing on the how of the intervention effect, the patterns of TTS use (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) were chosen as key variables on how the intervention was effective. This is based on the assumption that the TTS software use was effective for all students regardless of
disability status or ELL status. Since some individuals demonstrated reading gains, it was hypothesized that the differences in reading gains may be due to how students used the TTS software (i.e. tools). In addition, class/teacher implementation of the TTS software intervention and participants’ attitudes and perceptions about the TTS software use were investigated to determine why such differences in use, if there were any, were observed. In sum, from the results demonstrating the effectiveness of the TTS intervention, I was interested in investigating how students in the intervention group used the TTS software tools and why particular use of tools may have made the difference in reading gains. The following research questions were asked:

Restatement of the Research Questions:

1. How did the students’ patterns of TTS software use (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) differ by reading gain groups (i.e., HG, MG and NG)?
2. Why did the students’ patterns of TTS software use differ by reading gain groups?
   a. Did the teachers’ implementation impact the students’ patterns of TTS software use?
   b. Did students’ attitudes and perceptions towards the TTS software intervention impact their patterns of TTS software use?

Embedded Multiple Case Study

In order to answer the research questions, an embedded multiple case study design was used. Case studies are an investigation of “a specific, unique system with patterned behavior, dynamic properties, and defined features” (Curry, Nembhard, & Bradley, 2009, p. 1444). It is a study method that is useful in answering “how and why” questions to investigate a phenomenon in real-life contexts using multiple sources of evidence (Yin, 2009; Yin 2013).
There are several dimensions of the case study to be considered. First, case studies can be holistic or embedded. The holistic approach is mainly driven by qualitative methods relying on narrative and phenomenological descriptions (Scholz & Tietje, 2002). The embedded approach, on the other hand, is not limited to qualitative analysis and can be quantitative involving statistical analyses (Scholz & Tietje, 2002). The embedded approach is also useful where the case involves more than one unit. For the problem set forth in this study, the embedded approach was suitable as the individual student cases were embedded within class/teacher and embedded within the groups based on their reading gains (see Figure 2). Thus, with the embedded case design, the patterns of use were not only analyzed holistically at the group level, but also within, between and across the subunits (i.e., classes/teacher & students).

Secondly, case studies are classified as either a single case or multiple cases (Scholz & Tietje, 2002). As the word suggests, a single case study examines one individual or group. In investigating the patterns of the TTS software use, a single case would not have been sufficient to understand the patterns of use by those who made different gains in reading comprehension. A multiple case study allows for exploration of within and between cases (Yin, 2013). In order to find patterns of TTS software use that were effective by reading comprehension gains, multiple cases were selected to corroborate and strengthen the findings that specific patterns of TTS software use made the difference in the outcomes.

Finally, case studies may be exploratory, descriptive or explanatory (Curry, Nembhard, & Bradley, 2009; Yin, 2013). An exploratory case study is often used for hypothesis generating, preceding a final study (Scholz & Tietje, 2002). A descriptive case study uses a theory or model to depict a phenomenon within its context (Scholz & Tietje, 2002). An explanatory case design goes beyond describing a phenomena and can be used to identify cause-and-effect relationships.
Write cross case report on themes drawn across groups & across class/subjects.

Figure 2. An Embedded Multiple Case Study Design of 12 Cases.
(Curry et al., 2009); thus, this design can be used to answer how and why questions (Yin, 2013). The current study is explanatory in nature and strongly suggests a relationship between the students’ patterns of the TTS software use and the level of reading gains made in their reading comprehension with TTS intervention.

Based upon the research questions, an embedded multiple case design (Scholz, 2002, Scholz & Tietje, 2002) using both quantitative and qualitative data gathered from the Steppingstones Study were used to examine the patterns (i.e., duration of use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) of TTS software use with students by class type, and class type across the three reading gain groups. Within, between, and across subunits, class/teacher factors and student factors were also examined to corroborate the usage pattern. The intervention was implemented in an authentic secondary class environment. The class/teacher factors reflected the way in which the intervention was implemented as individual teaches may have presented and used the TTS software in their own ways. Student factors included students’ attitudes and perceptions towards the use of the TTS software.

**Participant Selection**

Prior to selecting specific cases, I first established a pool of possible student participants from the entire intervention group of students from the Steppingstones Study. Five semesters of participants were selected (i.e., Fall 2011, Spring 2012, Fall 2012, Spring 2013, Fall 2013) from the seven semesters of Steppingstones Study implementation between the years 2011-2013. Spring 2011 and Summer 2011 semester participants were omitted from the current study for the following reasons. During Spring 2011, the study used a different version of the TTS software (Kurzweil Network version versus Kurzweil V.12 Web version) for the intervention. From the
network version of Kurzweil, the same level of participant usage information was not available as the Web version. Participants from the Summer 2011 semester were also excluded from the study as the summer school class environment and setting were dissimilar to that of the regular school year class. Typical classes involved in the study met two or three times a week for 37 minutes to 120 minutes, whereas the summer school class met intensively every day for four weeks totaling 120 hours. Therefore, the students’ use of TTS software during the summer was qualitatively different from the regular Fall and Spring semesters.

Next, from the selected five semesters of data, student participants that used the Mac version of Kurzweil and those who used the TTS software for less than 30 minutes were also excluded from the study. Participants who used the Mac version of Kurzweil were not included because the data on specific tools use was not available from Mac users. Finally, students whose usage was under 30 minutes on average were also excluded from the current study as previous studies found that for TTS software intervention to be effective, the student should use the TTS software for at least 30 minutes per week (Roberts et al., 2012). Therefore, from the original 253 student participants who were in the Steppingstones Study intervention group, 162 student participants met inclusion criteria and were included for the case selection pool.

**Case Selection**

From the 162 students, I applied a stratified purposive sampling technique to select the 12 cases (Teddlie & Yu, 2007). A stratified purposive sampling is one of the basic mixed methods sampling strategies where the group of interest is divided into strata followed by a selection of cases to study within each strata (Teddlie & Yu, 2007). Therefore, prior to selecting the cases, participants were divided into strata or three groups based on each students’ reading comprehension gains – HG, MG, NG. The gains were measured by the difference between
subjects’ pre-post composite (comprehension and vocabulary scores) grade level equivalency (GLE) on the GMRT (MacGinitie, MacGinitie, Maria, & Dreyer, 2000). HG student data included those students who had higher than 1.0 GLE difference ($1.0 \leq \text{HG}$). MG student data included those students whose differences were between 0.1 to 0.9 GLE ($0 < \text{MG} < 1.0$). NG student data were those students who had no difference between the pre and post reading tests or a negative difference ($\text{NG} \leq 0$). Within each of the groups, the students were further grouped by class: (a) ELL (b) Language Arts (c) History, and (d) Science. Finally, from 12 strata (three levels of reading gain groups crossed by four groups of classes), 12 cases were selected from each of the strata that represented a “typical” case that demonstrated the best representatives of TTS software use within the group. To control for teacher variable, I used a systematic method to identify cases from the same teacher’s class for each of the reading gain groups for each of the class categories.

These 12 cases were selected systematically by following the steps outlined below:

1. Select a class from the four classes.
2. Review the HG cases from the selected class.
3. Review the pre-post GLE and identify case with the mean gain of about 1.6 GLE.
4. If there are more than one HG case that fit the criteria #3, select a case with most complete data (i.e., least amount of data missing).
5. Select the HG case.
6. Next, select a MG case from the same teacher’s class as selected HG case.
7. If there are more than one MG case from the same teacher’s class, review the pre-post GLE and identify the case with the mean gain of about 0.5 GLE.
8. If there are more than one MG case that fit the criteria #7, select a case with most complete data (i.e., least amount of data missing).

9. Select the MG case.

10. Finally, select a NG case from the same teacher’s class as selected HG and MG cases.

11. If there are more than one NG case, review the pre-post GLE and identify the case with the mean gain of about -0.4 GLE.

12. If there are more than one NG case that fit the criteria #11, select a case with most complete data (i.e., least amount of data missing).

13. Select the NG case.

14. Repeat steps 1-13 for the rest of the class categories.

Once the cases were selected, the students usage patterns were confirmed to not be considered outliers within their reading gains group. This sampling method was tested for reliability by another researcher unfamiliar with the study for 80% of the cases. For the 80% of the cases, the reliability in the selection was at 100% accuracy. The cases were sampled in such a way to allow for examination of the differences in the patterns of TTS software use by gains across a variety of class types. This sampling was also used to account for the differences in the text type by teacher/class that could have influenced the patterns of the TTS software use by students. Finally, after the 12 cases were selected systematically, I made sure that the sample included a range of struggling readers: Each reading gain group had to have at least one student who was identified as having a disability.

Data Collection

Regardless of the type of case study, the quality of a case study is enhanced by the use of diverse sources of information (Curry, Nembhard, & Bradley, 2009). The embedded approach
also affords multiple sources of data to address research questions (Johnson & Onwuegbuzie, 2004; Leech & Onwuegbuzie, 2009). In the current study, both quantitative and qualitative data from the Steppingstones Study were collected. The data sources for the case study included: reading test (i.e. GMRT), students’ pre-post surveys, teachers’ pre-post surveys, observation records, TTS software usage log, proficiency checklist, field/meeting notes, and annual reports. Table 4 summarizes the type of data that were used. All of the data used for this case study were collected during the Steppingstones Study. No additional or new data were collected directly from the participants of the Steppingstones Study.

The main quantitative data collected for analysis were the reading comprehension scores, and the TTS software usage log. The core qualitative data used were the observation notes and the students’ answers to open ended questions from their post survey. Although there was more emphasis on the use of the quantitative data in this study, the qualitative data were useful in going beyond identified variables that were statistically linked with a desired effect to understand how the TTS intervention was effective in improving reading comprehension.
Table 4

Summary of Data Sources Reviewed

<table>
<thead>
<tr>
<th>Data Source</th>
<th>QUAN or QUAL</th>
<th>Class Level</th>
<th>Student Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMRT</td>
<td>QUAN</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Student Pre-Survey</td>
<td>QUAN</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Student Post-Survey</td>
<td>QUAN + QUAL</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Teacher Pre-Survey</td>
<td>QUAN</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Teacher Post-Survey</td>
<td>QUAN + QUAL</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Student TTS usage log</td>
<td>QUAN</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Proficiency Checklist</td>
<td>QUAN</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observation Form</td>
<td>QUAN + QUAL</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Field Notes</td>
<td>QUAL</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Annual Reports</td>
<td>QUAN + QUAL</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note. QUAN = quantitative, QUAL = qualitative

Data Sources

Gates-MacGinitie Reading Test (GMRT) scores. GMRT 7/9 (MacGinitie, MacGinitie, Maria, & Dreyer, 2000) is a norm referenced, group or individually administered, paper-and-pencil, silent reading test. The vocabulary test of the GMRT includes 40 multiple-choice questions and is 20 minutes long. The comprehension subtests include 11 narrative and expository passages with a total of 48 multiple-choice questions. The comprehension subtest is 35 minutes long. For form S, MacGinitie et al. (2000) report internal reliability coefficients of .92 and .93; and report test-retest reliabilities of .90 for reading vocabulary, .74 for comprehension, and .88 for the total score.
For each case, both pre- and post- intervention GMRT scores were reviewed. The two scores were from a parallel form (i.e., S or T) of the GMRT that was administered at the beginning and at the end of their TTS software intervention. GMRT data included, students’ raw scores, percentile scores and GLE scores for vocabulary, comprehension, and combined total reading scores. The GMRT was administered in a pencil-paper format to the students without the use of the TTS software.

Although reading rate was not a part of the measure for GMRT, rate was calculated for each student as number of words read per minute using the first reading passage on the pre- and post-GMRT. The Steppingstones Study researchers asked the students to write the last three words read at the 30-seconds mark for the first passage.

**Student survey data.** Steppingstones Study researchers developed student pre-post surveys (Appendix D). The survey was administered at the beginning and at the end of the semester. The pre-survey data included information on students’ demographic characteristics, self-efficacy scales on reading, attitudes and perception towards using the TTS software, and prior experience using reading software. The post-survey data included the same questions on self-efficacy scales on reading, attitudes and perception towards using the TTS software, an evaluation of the TTS software, and three open-ended questions about students’ perceptions and attitudes towards TTS use after intervention.

**Teacher survey data.** Similar to the student survey data, Steppingstones Study researcher-developed teacher pre-post survey data were available (Appendix E). The survey was administered at the beginning and at the end of the semester. Both the pre- and post-survey included similar questions about (a) teachers’ perceptions of the usefulness of the TTS software as well as (b) the extent of their use of the software with their students. Pre-survey data also
included teachers’ demographic characteristics and course content area. Teacher surveys were reviewed to understand the context in which the TTS software was implemented.

**TTS software log.** The TTS software log was the main source of documentation used for the study. Kurzweil 3000 software automatically logged each students’ software use from the time they logged on to the time they logged off. Every action students took while on Kurzweil 3000 was recorded with a specific event code and a time stamp of when the action took place. Figure 3 is a screen shot of a partial time log showing one student’s use of Kurzweil 3000 on 4/12/12 from 9:17 am to 9:52 am. As can be seen from Figure 3, each time the student took an action in Kurzweil 3000, the software logged her action with a three-digit event code. Within a short period, this student used a few different tools. She first used the Reading Tool to start reading, and while reading, she adjusted the reading speed. She also used the Dictionary Tool to look up words and utilized the Study Skills Tool to highlight some parts of the text that she was reading.

<table>
<thead>
<tr>
<th>Logged On</th>
<th>Logged Off</th>
<th>Duration</th>
<th>Event Code/Action</th>
<th>Time of Action</th>
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<tbody>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>417-Reading Started</td>
<td>4/12/12 9:17</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>418-Reading Ended</td>
<td>4/12/12 9:51</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>420-Look up Definition</td>
<td>4/12/12 9:29</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>421-Definition Not Found</td>
<td>4/12/12 9:44</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>416-Reading Speed Changed</td>
<td>4/12/12 9:45</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>426-Spell a Word</td>
<td>4/12/12 9:32</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>448-Use Highlighter</td>
<td>4/12/12 9:36</td>
</tr>
<tr>
<td>4/12/12 9:17</td>
<td>4/12/12 9:52</td>
<td>0.58</td>
<td>448-Use Highlighter</td>
<td>4/12/12 9:42</td>
</tr>
</tbody>
</table>

*Figure 3.* A screenshot of an example Kurzweil 3000 usage log.

In total, there were a 119 unique event codes that were automatically recorded within Kurzweil 3000 software log (Appendix F). During the Steppingstones Study, from the 119 event codes, 32 codes were selected as relevant for the study; other codes included actions pertaining to scanning, adjusting scanned materials, assigning homework, and spelling, which were not part
of the study. The two codes, 417 (Reading Started) and 418 (Reading Ended) were used to measure the duration of reading in minutes. The other 30 codes were classified into four clusters of tools: (1) Reading Tools; (2) Dictionary Tools; (3) Study Skills Tools; and (4) Internet Tool. These four clusters of tools along with durations of TTS software use and reading minutes were examined in the current study. Table 5 shows the event codes and the actions by clusters of tools.

Table 5

*Four Clusters of Tools and its Associated Actions*

<table>
<thead>
<tr>
<th>Clusters</th>
<th>Event Code</th>
<th>Action</th>
<th>Action Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Tools</td>
<td>415</td>
<td>Reading Voice Changed</td>
<td>Changed speech synthesis voice output</td>
</tr>
<tr>
<td></td>
<td>416</td>
<td>Reading Speed Changed</td>
<td>Changed the rate (words per minute) at which the text is read out loud by the speech synthesis</td>
</tr>
<tr>
<td></td>
<td>419</td>
<td>Page Turned</td>
<td>Turned the page</td>
</tr>
<tr>
<td></td>
<td>443</td>
<td>Read Silently</td>
<td>Speech output was made silent with only dual highlighting</td>
</tr>
<tr>
<td></td>
<td>517</td>
<td>Reading Mode Changed</td>
<td>Changed reading output from word-by-word, self-paced, or continuous reading</td>
</tr>
<tr>
<td></td>
<td>518</td>
<td>Reading Unit Changed</td>
<td>Changed how the text is highlighted</td>
</tr>
<tr>
<td>Study Skills Tools</td>
<td>408</td>
<td>Extract to Column Notes</td>
<td>Extracted highlighted texts to create column notes</td>
</tr>
<tr>
<td></td>
<td>409</td>
<td>Extract Markup</td>
<td>Extracted highlighted and circled texts into a new document</td>
</tr>
<tr>
<td></td>
<td>410</td>
<td>Extract Text</td>
<td>Extracted highlighted texts into a new document</td>
</tr>
<tr>
<td></td>
<td>411</td>
<td>Extract Column Notes to Outline</td>
<td>Extracted column notes text into an outline format</td>
</tr>
<tr>
<td></td>
<td>448</td>
<td>Use Highlighter</td>
<td>Used highlighters to mark up text</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>Add Footnote</td>
<td>Used footnotes to type answers, questions, etc.</td>
</tr>
<tr>
<td></td>
<td>451</td>
<td>Add Sticky Note</td>
<td>Used sticky notes to insert question, notes, etc. about the text</td>
</tr>
<tr>
<td></td>
<td>452</td>
<td>Add Bubble Note</td>
<td>Used bubble notes to embed questions, comments, etc.</td>
</tr>
</tbody>
</table>
For the current study, the unit of analysis was at the cluster level, and therefore the patterns of students’ use of the tools were based on these four clusters. Each cluster is explained in detail below.

**Reading Tools.** Reading Tools are the tools to assist with the reading and are the main feature of most TTS software. Within the Reading Tools, the students can adjust voice, speed, and units of reading. There are a number of voice options that range from robotic speech to a more naturally sounding voice, and the reading rate (words per minute) at which the text is read

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>453</td>
<td>Add Text Note</td>
<td>Used text notes to insert answers, comments, etc.</td>
</tr>
<tr>
<td>454</td>
<td>Highlight with Word List</td>
<td>Highlighted the words in a specific word list</td>
</tr>
<tr>
<td>456</td>
<td>Open Bubble Note</td>
<td>Opened bubble notes embedded in the text</td>
</tr>
<tr>
<td>462</td>
<td>Create a Bookmark</td>
<td>Created a bookmark to mark places in the text</td>
</tr>
<tr>
<td>463</td>
<td>Follow a Bookmark</td>
<td>Jumped to the bookmark created in the text</td>
</tr>
<tr>
<td>474</td>
<td>Column Notes - New</td>
<td>Created a new column notes while reading</td>
</tr>
<tr>
<td>475</td>
<td>Column Notes - Open</td>
<td>Opened an existing column notes while reading</td>
</tr>
<tr>
<td><strong>Dictionary Tools</strong></td>
<td>420</td>
<td>Look up Definition</td>
</tr>
<tr>
<td></td>
<td>421</td>
<td>Definition Not Found</td>
</tr>
<tr>
<td></td>
<td>422</td>
<td>Look Up in Encarta</td>
</tr>
<tr>
<td></td>
<td>423</td>
<td>Get Synonyms</td>
</tr>
<tr>
<td></td>
<td>424</td>
<td>Synonyms not Found</td>
</tr>
<tr>
<td></td>
<td>425</td>
<td>Hear Syllables for Word</td>
</tr>
<tr>
<td></td>
<td>482</td>
<td>Selected Dictionary</td>
</tr>
<tr>
<td></td>
<td>489</td>
<td>Online Reference Lookup</td>
</tr>
<tr>
<td><strong>Internet Tool</strong></td>
<td>444</td>
<td>Read the Web invoked</td>
</tr>
</tbody>
</table>
out loud by the speech synthesis can be manually adjusted at any time. While the text is being read, the text is also highlighted. The amount of text that is highlighted can be adjusted to word, phrase, line, sentence or a paragraph. In addition, the reading mode can be adjusted so that the speech synthesis would read continuously, word-by-word or at a self-paced rate. The ‘Read Silently’ means that the students stopped the audio output of the speech synthesis but followed the dual highlighting. The TTS log only logged the frequency in which the students adjusted or used the tools while reading and it did not capture how the students adjusted the tools. For example, there is no record of the rate the student set the speech synthesis to in reading and how he/she adjusted while reading. The only information that is logged is that the student adjusted the speed.

Figure 4. A screenshot of an example use of Study Skills Tools such as highlighting, circling, a footnote, a text note, and a sticky note.

**Study Skills Tools.** Study Skills cluster includes tools that support strategic reading. There are two main types of tools, annotation tools and extracting tools. The annotation tools are where students can use various tools to ‘write’ directly onto the text while reading (See Figure
4). These include highlighting, footnotes, sticky notes, bubble notes, column notes and text notes. ‘Extract’ actions are when students extract any of their annotation markups (highlights, footnotes, sticky notes, bubble notes) and create a new separate text document that they can use for studying, writing essays, or answering questions.

**Dictionary Tools.** Dictionary Tools are for looking up words in the dictionary, thesaurus, encyclopedia, or a resource online. There are several dictionaries embedded within Kurzweil 3000. While reading, students can click on the word that they are unsure of and choose a dictionary to look up the word. A separate dictionary window will open providing pronunciation and definitions. The speech synthesis is enabled while using the dictionary and will read the definition back to the students.

**Internet Tool.** The Internet Tool was available for students to browse the Web from Kurzweil 3000 so that the Reading Tools could be used.

**Proficiency checklist data.** During the Steppingstones Study, proficiency self-checklist was administered to the intervention group students and teachers immediately and two weeks after training on the use of the TTS software. In the current study, this information was used to review students’ mastery of the TTS software use as their mastery could have interfered with the use of the TTS software. This self-report checklist assessed students’ ability to use the software independently at a 95% mastery level.

**Observation data.** Observational records from the Steppingstones Study were reviewed to corroborate students’ TTS software use and the context in which the TTS software was used. During the Steppingstones Study, the participating teachers’ classes were observed two to three times a semester by two research staff each time. Researchers used a researcher developed
observation form to record the class reading activity, student engagement level, and teacher and students’ use of the TTS software (Appendix G).

**Field notes.** Staff field notes from the Steppingstones Study were collected to review the TTS software intervention implementation process. These were available as an archived Google Doc. The notes were recorded on a regular basis by the Steppingstones Study research staff to monitor their project activities. These notes also captured successes and challenges of the TTS intervention implementation.

**Annual report.** Steppingstones Study’s annual reports were reviewed for data corroboration.

**Data Analysis**

A graphical approach was utilized to visually represent and analyze the patterns of the TTS software use. Graphs are useful to show general patterns that are important rather than the actual data values (Oxford Consultants for Social Inclusion, 2009). Tufte (2001) states that when using graphical display, the display should “encourage the eye to compare different pieces of data” and “make large data sets coherent” (p.13). Specifically, radar charts or sometimes called spider graphs were utilized to visually investigate the patterns of the TTS software use. Radar charts are useful when comparing multiple variables simultaneously (Mosley & Mayer, 1998). With the radar chart, all six indices of the students’ TTS software use can be graphically displayed. Thus, using the radar charts, the weekly average of the following six indices were visually analyzed at both the group level and for each individual cases: (a) duration of TTS software use in minutes (Average Total Min.), (b) duration of reading with TTS in minutes (Average Reading Min.), (c) frequency of reading tools use (Average Reading Tools), (d) frequency of study skills tools use (Average Study Skills Tools), (e) frequency of dictionary
tools use (Average Dictionary Tools), and (g) frequency of Internet/Web tool use (Average Internet Tool).

**Group Level Analysis**

In answering research questions 1 & 2, prior to analyzing each individual case in this study, group level data were used to identify group characteristics and general trends and patterns of the TTS software usage by reading gain groups (HG, MG, NG). Yin (2003) suggests that empirical data be used to determine if patterns emerge and are aligned across cases. These patterns potentially strengthen the internal validity of the case study. IBM SPSS Statistics was utilized to conduct a basic descriptive analysis of each of the groups. An one way analysis of variance (ANOVA) was conducted to determine whether there was an overall difference between groups with regard to student level factors and the TTS software tool use. All output were summarized into tables and radar charts were used to depict the group pattern for referencing in analyzing within and between cases at the individual and class level.

**Within Case Analysis**

Once the group analysis was conducted, pattern-matching analytic technique (Trochim, 1989; Yin, 2003) and a cross-case synthesis (Yin, 2003) was utilized to organize and analyze the individual case data. Both quantitative and qualitative data were analyzed for each of the cases.

In an embedded study, the analysis is recommended to begin at the single case level for each sub-unit rather than pooling across cases (Yin, 2003). Therefore, within level analysis was conducted independently at the student level and the class level. Next, a between level analysis was conducted, emphasizing the relationships between the student level and class level patterns. For each of the cases, a radar chart was used to visually show the pattern of the TTS software use. This was further compared to the descriptive statistic output of the particular group.
For qualitative data analysis, such as open-ended questions for students’ attitudes and perceptions and field notes, a manual constant comparative method of analysis (Glaser & Strauss, 1967) was used. The information was reviewed and organized based on codes for each unit of data. The coded data were then combined into meaningful categories to identify themes and trends.

**Cross Case Analysis**

Cross case analysis is the core of the multiple case study (Yin, 2009) and in answering the research questions. The radar chart for each individual case was mapped across cases for pattern matching and explanation building to identify the differences in the TTS usage patterns, if any, by those who made high gains, moderate gains and no or negative gain in reading comprehension.

**Study Validation**

Just as in any empirical research, construct validity, internal validity, external validity and reliability must be addressed in case study designs (Phondej, Kittisarn, & Neck, 2011). Construct validity was addressed by using multiple sources of evidence and having a member of the Steppingstones Study review a draft of the case study report. As this was an explanatory case study, internal validity was also addressed by conducting systematic pattern-matching and explanation building during the data analysis phase (Yin, 2009).

External validity is to test “whether a study’s findings are generalizable beyond the immediate case study” (Yin, 2009, p.43). Although generalizability is a challenge with case studies, some aspect of this was addressed by having multiple cases in the study and establishing a “replication logic.” After results were obtained, literal replication (Yin, 2014) was conducted to three additional cases to see if similar patterns of TTS software use were obtained.
Additionally, the participants were selected from the large experimental study where inclusion and exclusion criteria were already delineated. Furthermore, the study was conducted in an authentic school setting; therefore, the study results are likely generalizable and applicable to students in similar Hawai`i schools or to other schools similar to that of Hawai`i.

Finally, to address reliability, the procedure of this study was clearly documented and a case study database was developed. A clear procedure/protocol will allow for other investigators to replicate procedures.

In sum, an embedded multiple case study design was used. Twelve cases were selected from 162 cases for in depth analysis. A radar chart technique was applied to investigate the patterns of the TTS software use.
CHAPTER 4

FINDINGS

In this section, I first present the overall group composition and demographic data to provide an overview of the whole intervention group. Subsequently, I present the findings to the two research questions. The findings of Research Question 1 provide results of the group level pattern of the TTS software use, followed by within case narratives on patterns of use by each of the 12 cases. In the within case narratives, I use a pattern-matching technique to corroborate the group findings with the individual cases. Finally, I present the findings for Research Question 2 by examining cross case themes.

Overall Group Composition

A total of 162 students’ data met the inclusion criteria for the current study. These student participants’ data represented students from eight high schools on Oahu, Hawai`i. Table 6 shows the number of students from each of the schools.

Table 6

Number of Student Participants at Each School (n=162)

<table>
<thead>
<tr>
<th>School</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27</td>
<td>16.7</td>
</tr>
<tr>
<td>B</td>
<td>46</td>
<td>28.4</td>
</tr>
<tr>
<td>C</td>
<td>26</td>
<td>16.0</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
<td>7.4</td>
</tr>
<tr>
<td>E</td>
<td>29</td>
<td>17.9</td>
</tr>
<tr>
<td>F</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>G</td>
<td>6</td>
<td>3.7</td>
</tr>
<tr>
<td>H</td>
<td>12</td>
<td>7.4</td>
</tr>
<tr>
<td>Total</td>
<td>162</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Overall Group Demographics

From the demographic survey of the 162 participants, gender, disability status, and language use are summarized in Table 7. Not all students answered all of the questions. Of those who responded (n=140), 58.6% of the students were males and 41.4% were females. With respect to students’ disability status, of those who responded (n=146), 50.7% responded that they have an IEP or a 504 Plan. 49.3% of answered that they do not have an IEP or a 504 Plan. With regard to language use at home, of the students those who responded (n=141), 48.9% of the students use English only at home; 27.7% reported that they use another language other than English at home; and 23.4% responded that they use both English and another language at home.

Table 7

Demographics of All Student Participants (n=162)

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Overall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>82</td>
<td>58.6</td>
</tr>
<tr>
<td>Female</td>
<td>58</td>
<td>41.4</td>
</tr>
<tr>
<td>Missing</td>
<td>22</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Disability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>74</td>
<td>50.7</td>
</tr>
<tr>
<td>No</td>
<td>72</td>
<td>49.3</td>
</tr>
<tr>
<td>Missing</td>
<td>16</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Language at Home</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Only</td>
<td>69</td>
<td>48.9</td>
</tr>
<tr>
<td>Non-English Only</td>
<td>39</td>
<td>27.7</td>
</tr>
<tr>
<td>English &amp; Non-English</td>
<td>33</td>
<td>23.4</td>
</tr>
<tr>
<td>Missing</td>
<td>21</td>
<td>NA</td>
</tr>
</tbody>
</table>

*BThe percent values given are “valid percent” calculated based on students who responded to the question on the demographic survey.*

*bNA= not applicable. Missing data were not included in calculating the “valid percent.”
Reading Gain Group Composition

Three distinct reading gain groups emerged based on the students’ differences in the pre-post Total Reading Comprehension GLE of the GMRT. The Total GMRT score is the composite score of the vocabulary and the comprehension test scores (MacGinitie et al., 2000). The difference between the pre-post GLE was considered as the students’ reading gain. Participating students were classified as HG if their gain was 1.0 GLE or higher; MG, if their gain were between 0.1 GLE and 0.9 GLE; and NG, if there was no gain (i.e. 0.0 GLE) or if their gain was a negative gain. Table 10 summarizes the breakdown of the students by groups and their reading gain profile. Of the 162 student participants, 26.5% or 43 students had the pre-post reading comprehension GLE difference of 1.0 or higher and was classified as HG. The mean GLE difference for the HG was 1.69 GLE (SD= 0.56) and ranged from 1.0 GLE to 3.2 GLE. The median GLE was 1.60. 30.1% or 50 students represented the MG group. The mean GLE difference was 0.51 GLE (SD=0.24) and ranged from 0.10 GLE to 0.90 GLE. The median GLE was .50. Lastly, 42.6% or 69 students had 0.0 or a negative pre-post reading comprehension GLE difference (NG ≤ 0.0). The mean GLE difference was -0.53 GLE (SD=0.43) and ranged from -1.8 GLE to 0.0 GLE. The median GLE was -0.40.

Table 8

Reading Gain Profile by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>HG</td>
<td>43</td>
<td>1.69</td>
<td>0.56</td>
<td>1.00</td>
<td>3.20</td>
<td>1.60</td>
</tr>
<tr>
<td>MG</td>
<td>50</td>
<td>0.51</td>
<td>0.24</td>
<td>0.10</td>
<td>0.90</td>
<td>0.50</td>
</tr>
<tr>
<td>NG</td>
<td>69</td>
<td>-0.53</td>
<td>0.43</td>
<td>-1.80</td>
<td>0.00</td>
<td>-0.40</td>
</tr>
<tr>
<td>Overall</td>
<td>162</td>
<td>0.38</td>
<td>1.00</td>
<td>-1.80</td>
<td>3.20</td>
<td>0.30</td>
</tr>
</tbody>
</table>
Figure 5 provides boxplots to visually represent the distribution of the GLE gain for each of the groups. This shows that there were four outliers in the HG and NG groups. Although the outliers were included, the mean reading gain differences amongst the three reading gain groups (HG, MG, & NG) was statistically significant, Welch’s $F(2, 277.111) = 88.830, p<.001$.

![Boxplots of GLE differences for reading gain groups](image)

**Figure 5.** Boxplots to illustrate the spread of GLE differences of the three gain groups.

**Reading Gain Group Demographics**

The demographic information for each reading group is summarized in Table 9.

**HG demographics.** Of the 37 respondents, 64.9% (24) were males and 35.1% (13) were females. Of the 38 HG students who responded, 52.6 % (20) had an IEP or Section 504 Plan and 47.4% (18) responded that they did not have an IEP or Section 504 Plan. With regard to language use at home, of the 36 students who responded, 55.6% (20) said that they used English
only, 16.7% (6) indicated that they used another language other than English at home, and 27.8% (10) responded that they used both English and another language at home.

Table 9

Demographics of Participants by Reading Gain Groups - HG (n=43), MG (n=50) & NG (n=69)

<table>
<thead>
<tr>
<th>Demographics</th>
<th>HG n</th>
<th>%</th>
<th>MG n</th>
<th>%</th>
<th>NG n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24</td>
<td>64.9</td>
<td>22</td>
<td>50.0</td>
<td>36</td>
<td>61.0</td>
</tr>
<tr>
<td>Female</td>
<td>13</td>
<td>35.1</td>
<td>22</td>
<td>50.0</td>
<td>23</td>
<td>39.0</td>
</tr>
<tr>
<td>Missing</td>
<td>6</td>
<td>NA^b</td>
<td>6</td>
<td>NA</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>Disability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>20</td>
<td>52.6</td>
<td>22</td>
<td>48.9</td>
<td>32</td>
<td>50.8</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>47.4</td>
<td>23</td>
<td>51.1</td>
<td>31</td>
<td>49.2</td>
</tr>
<tr>
<td>Missing</td>
<td>5</td>
<td>NA</td>
<td>5</td>
<td>NA</td>
<td>6</td>
<td>NA</td>
</tr>
<tr>
<td>Language at Home</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Only</td>
<td>20</td>
<td>55.6</td>
<td>17</td>
<td>39.5</td>
<td>32</td>
<td>51.6</td>
</tr>
<tr>
<td>Non-English</td>
<td>6</td>
<td>16.7</td>
<td>17</td>
<td>39.5</td>
<td>16</td>
<td>25.8</td>
</tr>
<tr>
<td>English &amp; Non-English</td>
<td>10</td>
<td>27.8</td>
<td>9</td>
<td>20.9</td>
<td>14</td>
<td>22.6</td>
</tr>
<tr>
<td>Missing</td>
<td>7</td>
<td>NA</td>
<td>7</td>
<td>NA</td>
<td>7</td>
<td>NA</td>
</tr>
</tbody>
</table>

^aThe percent values given are “valid percent” calculated based on students who responded to the question on the demographic survey.

^bNA= not applicable. Missing data were not included in calculating the “valid percent.”

**MG demographics.** Of the 44 respondents, 50% (22) were males and 50% (22) were females. Of the 45 who responded, 48.9% (22) had an IEP or Section 504 Plan and 51.1% (23) responded that they did not have an IEP or Section 504 Plan. With regard to language use at home, of the 43 students who responded, 39.5% (17) said that they use English only, 39.5% (17) indicated that they used another language other than English at home, and 20.9% (9) responded that they used both English and another language at home.

**NG demographics.** Of the 59 respondents, 61.0% (36) were males and 39.0% (23) were females. Of the 63 students who responded, 50.8% (32) had an IEP or Section 504 Plan and
49.2% (31) responded that they did not have an IEP or Section 504 Plan. With regard to language use at home, of the 62 students who responded, 51.6% (32) said that they used English only, 25.8% (16) indicated that they use another language other than English at home, and 22.6% (14) responded that they use both English and another language at home.

**Data Analysis by Research Question**

**Research Question 1**

How did the students’ patterns of TTS software use (i.e., duration of TTS software use, reading minutes, and frequency of Reading Tools, Study Skills Tools, Dictionary Tools, and Internet Tool use) differ by reading gain groups?

**TTS use by reading gains.** From the TTS software usage log, the patterns of use by HG, MG, and NG students were examined on six indices: (1) average total TTS software usage in minutes (Average Total Min.); (2) duration of average reading in minutes (Average Reading Min.); (3) average Reading Tools usage frequency (Average Reading Tools); (4) average Study Skills Tools usage frequency (Average Study Skills Tools); (5) average Dictionary Tools usage frequency (Average Dictionary Tools); and (6) average Internet/Web browsing usage frequency (Average Internet Tool). The total number of intervention weeks varied from four to 14 weeks by participants. Therefore, for each of the six indices, the patterns of use were analyzed based on the average results per week only. With regard to the total number of intervention weeks, a one-way ANOVA was conducted to determine if there was a difference between the mean numbers of weeks for each group. There was no statistically significant difference in the mean total number of intervention weeks amongst the reading gain groups, F (2,159)=1.318, p =.271.

Table 10 summarizes the duration of TTS program use, duration of reading minutes, frequency of Reading Tools use, Study Skills Tools use, and Internet Tool use by reading gain
groups. Frequencies of tools use were not rounded to a whole number to depict the subtle differences amongst the three groups.

**HG use.** On average, HG students used the TTS software for 7.5 (SD=2.0) weeks totaling 587.1 minutes (SD=278.4), which was approximately 79.3 minutes of Total TTS log-in time per week. On average, students read with the TTS software for 347.7 minutes (SD=194.0) averaging 48.8 minutes per week. While reading, students on average accessed the Reading Tools 220.0 times (SD=148.2), which was on average 30.3 times per week. Students also used the Study Skills Tools on average 62.6 times (SD=121.8) averaging 8.8 times per week. On average, students used the dictionary tools 14.2 times (SD=21.4) averaging 1.9 times per week. Finally, HG students on average used the TTS software to access the Internet 2.4 times (SD = 5.9) averaging .3 times per week.

**MG use.** On average, MG students used the TTS software for 8.2 (SD=1.9) weeks with a total log-in time of 808.1 (SD=567.5) minutes, which was approximately 95.4 minutes per week. On average, students read with the TTS software for 273.7 minutes (SD=222.5) averaging 33.1 minutes per week. Students accessed the Reading Tools on average 280.0 times (SD=208.7) averaging 33.9 times per week. On average, students used the Study Skills Tools 118.1 times (SD=194.1) averaging 14.1 times per week. On average, students used the Dictionary Tools 30.1 times (SD=42.5) averaging 3.6 times per week. Finally, MG students on average used the TTS software to access the Internet 6.1 times (SD = 14.6) averaging .9 times per week.

**NG use.** On average, NG students used the TTS software for 7.9 (SD=2.3) weeks with a total log-in time of 697.1 (SD=460.3) minutes on average, which was approximately 90.0 minutes per week. On average, students read with the TTS for 291.3 minutes (SD=264.1) averaging 36.8 minutes per week. On average, students used the Reading Tools for 273.4 times
(SD=204.2) averaging at 36.4 times per week. On average, students used the Study Skills Tools 89.6 times (SD=175.5) averaging 11.2 times per week. On average, students used the Dictionary Tools 25.8 times (SD=35.3) averaging 3.3 times per week. Finally, NG students, on average, used the TTS software to access the Internet 3.5 times (SD = 7.4) averaging .5 times per week.

Table 10

*Summary of the Mean TTS Software Use by Reading Gain Group*

<table>
<thead>
<tr>
<th></th>
<th>HG</th>
<th>SD</th>
<th>MG</th>
<th>SD</th>
<th>NG</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TTS Usage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Weeks</td>
<td>7.5</td>
<td>2.0</td>
<td>8.2</td>
<td>1.9</td>
<td>7.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Total Minutes</td>
<td>587.1</td>
<td>278.4</td>
<td>808.1</td>
<td>567.5</td>
<td>697.1</td>
<td>460.3</td>
</tr>
<tr>
<td>Av. Total Minutes/wk</td>
<td>79.3</td>
<td>31.3</td>
<td>95.4</td>
<td>61.8</td>
<td>90.0</td>
<td>59.0</td>
</tr>
<tr>
<td>Total Reading Minutes</td>
<td>347.7</td>
<td>194.0</td>
<td>273.7</td>
<td>222.5</td>
<td>291.3</td>
<td>264.1</td>
</tr>
<tr>
<td>Av. Reading Minutes/wk</td>
<td>48.8</td>
<td>29.3</td>
<td>33.1</td>
<td>23.6</td>
<td>36.8</td>
<td>29.6</td>
</tr>
<tr>
<td>Total Reading Tools</td>
<td>220.0</td>
<td>148.2</td>
<td>280.0</td>
<td>208.7</td>
<td>273.4</td>
<td>204.2</td>
</tr>
<tr>
<td>Av. Reading Tools/wk</td>
<td>30.3</td>
<td>22.9</td>
<td>33.9</td>
<td>22.7</td>
<td>36.4</td>
<td>29.6</td>
</tr>
<tr>
<td>Total Study Skills Tools</td>
<td>62.6</td>
<td>121.8</td>
<td>118.1</td>
<td>194.1</td>
<td>89.6</td>
<td>175.5</td>
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<tr>
<td>Av. Study Skills Tools/wk</td>
<td>8.8</td>
<td>15.4</td>
<td>14.1</td>
<td>21.7</td>
<td>11.2</td>
<td>20.1</td>
</tr>
<tr>
<td>Total Dictionary Tools</td>
<td>14.2</td>
<td>21.4</td>
<td>30.1</td>
<td>42.5</td>
<td>25.8</td>
<td>35.3</td>
</tr>
<tr>
<td>Av. Dictionary Tools/wk</td>
<td>1.9</td>
<td>2.5</td>
<td>3.6</td>
<td>5.2</td>
<td>3.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Total Internet Tool</td>
<td>2.4</td>
<td>5.9</td>
<td>6.1</td>
<td>14.6</td>
<td>3.5</td>
<td>7.4</td>
</tr>
<tr>
<td>Av. Internet Tool/wk</td>
<td>0.3</td>
<td>0.7</td>
<td>0.9</td>
<td>2.8</td>
<td>0.5</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Note.* Av. = Average wk=week

**Comparison of the group patterns.** A radar chart was used to illustrate the TTS software weekly patterns as a whole based on the six indices. Figure 6 is a radar chart of the patterns of TTS use by HG, MG, and NG based on the average duration and tools use per week. From the radar chart, the MG and NG configurations are almost identical whereas the overall group HG students’ average TTS use pattern has a visually different configuration than that of
the MG and NG configurations. The most obvious difference is the longer average Reading minutes for the HG in comparison to that of the MG and the NG. Statistically, the mean differences of the average Reading minutes were also examined. The result of a one-way ANOVA confirmed that there is a statistically significant difference between the reading gain groups with regard to average Reading minutes, $F(2,159)=3.89, p<0.05$. From Tukey post hoc analysis, the differences were between the MG and HG, and this difference was statistically significant ($p=.022$). No other group differences were statistically significant.

![Average patterns of TTS software use of the three reading gain groups.](image)

*Figure 6.* The average patterns of TTS software use of the three reading gain groups.

The HG group on average also has shorter Average Total Minutes and less frequent use of all of the Tools (Reading, Study Skills, Dictionary, and Internet). Although the differences are visually noticeable, the mean differences on these indices are not statistically significant.

**Within Reading Gain Group Results**

Demographic characteristics and their reading comprehension gains of the 12 cases are summarized in Table 11 to provide an overview of all the cases.
<table>
<thead>
<tr>
<th>Case</th>
<th>M/F</th>
<th>Ethnicity</th>
<th>IEP/504 Plan</th>
<th>Language Use at Home</th>
<th>Pre GMRT GLE</th>
<th>Post GMRT GLE</th>
<th>Pre-Post GLE Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HG</td>
<td>Jesse</td>
<td>M</td>
<td>Pacific Islander</td>
<td>N</td>
<td>English Only</td>
<td>5.8</td>
<td>7.5</td>
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<tr>
<td>Mia</td>
<td>F</td>
<td>Asian</td>
<td>Y</td>
<td>English Only</td>
<td>4</td>
<td>5.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Aiden</td>
<td>M</td>
<td>Asian</td>
<td>N</td>
<td>Non-English Only</td>
<td>4.8</td>
<td>6.4</td>
<td>1.7</td>
</tr>
<tr>
<td>Terry</td>
<td>F</td>
<td>Native Hawaiian</td>
<td>Y</td>
<td>English Only</td>
<td>6.4</td>
<td>8.1</td>
<td>1.6</td>
</tr>
<tr>
<td>MG</td>
<td>John</td>
<td>M</td>
<td>Asian</td>
<td>N</td>
<td>English and Non-English</td>
<td>6.1</td>
<td>6.9</td>
</tr>
<tr>
<td>Tren</td>
<td>F</td>
<td>Asian</td>
<td>N</td>
<td>Non-English Only</td>
<td>3.8</td>
<td>4.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Cameron</td>
<td>M</td>
<td>Asian</td>
<td>N</td>
<td>Non-English Only</td>
<td>5.8</td>
<td>6.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Kim</td>
<td>F</td>
<td>Asian</td>
<td>Y</td>
<td>English Only</td>
<td>4.8</td>
<td>5.5</td>
<td>0.7</td>
</tr>
<tr>
<td>NG</td>
<td>Tom</td>
<td>M</td>
<td>Pacific Islander</td>
<td>N</td>
<td>English &amp; Non-English</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>Hank</td>
<td>M</td>
<td>Asian</td>
<td>N</td>
<td>English Only</td>
<td>6.7</td>
<td>6.4</td>
<td>-0.3</td>
</tr>
<tr>
<td>Nobu</td>
<td>M</td>
<td>Mixed</td>
<td>Y</td>
<td>English Only</td>
<td>2.6</td>
<td>2.4</td>
<td>-0.2</td>
</tr>
<tr>
<td>Vilma</td>
<td>F</td>
<td>Native Hawaiian</td>
<td>Y</td>
<td>English Only</td>
<td>5.6</td>
<td>5.5</td>
<td>-0.1</td>
</tr>
</tbody>
</table>

*Note.* M/F = Male/Female    IEP = Individualized Education Plan    Y/N=Yes/No    GMRT = Gates McGinitie Reading Test    GLE = Grade Level Equivalency    HG = High Gain    MG = Moderate Gain    NG=No/Negative Gain
**HG students’ patterns.** Jesse, Mia, Aiden, and Terry’s cases were examined as “typical” HG students representing four different teachers’ classes. Each of their TTS software use is described in depth. Using a radar chart, each of their patterns of the TTS software use is mapped onto the average HG TTS usage pattern to visually examine the differences and similarities.

**Jesse.** Jesse was in the ELL Language Arts class at School A. He responded to the survey that he only uses English at home although he was classified as an ELL student. He marked his ethnicity as Pacific Islander. He answered that he did not have an IEP or a 504 Plan. Jesse’s pre-post Total Comprehension GLE changed from 5.7 GLE to 7.5 GLE with a 1.8 GLE gain over one semester.

During the intervention, Jesse used the software for six consecutive weeks. His total TTS usage minutes was 512 minutes averaging 85.3 minutes per week. His minutes usage ranged from 12 minutes to 164 minutes per week. Each time that he logged on to the TTS software, he used the speech synthesis to “read.” Thus, Jesse’s total reading minutes was the same as the total usage minutes. For the Reading Tools, he mostly used one tool, which was to adjust the reading speed. The TTS log showed that he adjusted the speed a couple of times at each login. During the first weeks of intervention, Jesse adjusted the speed over 20 times in one sitting, and also used other various tools such as changing the voice, and adjusting the reading unit (one word, sentence, or paragraph, etc.). After the first week, however, his record showed that he hardly used other TTS tools except for looking up a word using a Dictionary Tool at each log-in and adjusting the speed using a Reading Tool.

From the radar chart, Jesse’s overall pattern does not match the average HG patterns of TTS software use (See Figure 7). The two patterns have dissimilar configurations. Of the six
categories, Jesse’s pattern and the average HG pattern overlaps on Average Total Minutes and Average Dictionary Tools.

![Diagram showing overlap of Jesse’s and HG patterns](image)

*Figure 7.* Jesse’s pattern of TTS use compared to the average HG pattern of TTS use.

**Mia.** Mia is an Asian female student who answered that she uses only English at home. She reported having an IEP or a Section 504 Plan, but did not know her disability. Mia’s Total Reading Comprehension score improved from 4.0 GLE to 5.5 GLE, a 1.5 GLE gain over one semester.

She used the TTS software in her English class for six consecutive weeks totaling 567.6 minutes, averaging 94.6 minutes per week of usage. During the six weeks, TTS software was used under three conditions: teacher-directed whole class instruction or student-directed independent use or mixture of both. Mia independently used the software for five weeks and as a class, she was also exposed to the TTS software for five weeks. There was only one week in which she did not use the software on her own. Overall, on average, she read with the TTS software for 74.3 minutes, used the Reading Tools 77 times per week, used the Study Skills
Tools 21.7 times per week, and used the Dictionary Tools 9.7 times per week. Her use of the tools increased as the weeks passed by. The TTS log showed that when she used the Reading Tools, she used a tool to adjust the reading speed and also a tool to adjust the voice. For the Study Skills Tools, Mia used a tool to highlight, but towards the end of her intervention weeks, she also used a tool to add voice note, a tool to add sticky note, and a tool to add a column note. Mia used the Dictionary Tools on her own as well as with the whole class during weeks three, four and five. The Dictionary Tools she used were to look up the words, but also to hear syllables/pronunciation for the words. She did not access the Internet, but her teacher accessed the Internet one time with the whole class.

From the radar chart, overall Mia’s average pattern of TTS software use has a similar configuration to that of the average HG pattern of TTS software use (see Figure 8). Five of the six categories are similar proportionately. The one category that is different is Mia’s use of the Reading Tools, which is approximately three times the average HG Reading Tools use.

![Figure 8. Mia’s pattern of TTS use compared to the average HG pattern of TTS use.](image)
**Aiden.** Aiden is an Asian male student who answered that he only uses English at home. He responded that he did not have an IEP or a 504 Plan. Aiden’s Total Comprehension GLE changed from 6.4 GLE to 8.1 GLE, a 1.7 GLE gain over a semester.

Aiden used the software for 10 weeks independently in an inclusion World History class. His total TTS usage minutes was 391 minutes averaging 39.12 minutes per week. His minutes usage ranged from 19.8 minutes to 82.8 minutes per week. The TTS log indicated that each week that he was logged on to the TTS software, he used the speech synthesis to read with the software. Thus, Aiden’s Total Reading Minutes was the same as the Total usage minutes. The log showed that Aiden consistently used the Reading Tools averaging 32.4 times per week. He used the Reading Tools not only to adjust the speed, but also to change the voice of the reader. He used the Study Skills Tools on average 1.6 times per week, but upon close examination of his log, he used the tools during three of the 10 weeks. He used the Dictionary Tools two times during his first week and used it no other time. He accessed the Internet one time.

Aiden’s pattern of TTS software use does not visually match the average HG patterns of TTS software use as illustrated in the radar chart (Figure 9). The only category that overlaps completely with the HG pattern is Aiden’s use of the Average Reading Tools. No other category overlaps with one another.
**Terry.** Terry is a female, multi-ethnic student, who responded that she speaks English only at home. She reported having an IEP for visual impairment. Her pre-post Total Reading Comprehension GLE changed from 4.8 to 6.4 GLE, gaining 1.6 GLE over one semester. She used the TTS software in a Physical Science class for students receiving special education services.

Terry used the TTS software for nine weeks. Of the nine weeks, she used the TTS software on her own for five weeks. She was exposed to the TTS software during whole class instruction for the entire nine weeks, however. The total minutes used over the nine weeks was 441 minutes with an average of 49 minutes per week. Her minutes usage ranged from eight minutes to 72 minutes per week. The average Reading minutes was rather short at 6.7 minutes per week. The TTS log indicated that the Reading Tools usage was 28.8 times per week. However, week to week usage showed that there was one week where the teacher used the Reading Tools for 133 times. The rest of the weeks, the Reading Tools were only used between
three to nine times. One of the main Reading Tools that Terry used was a tool to adjust the reading speed. Terry did not use the Study Skills Tools or the Dictionary Tools on her own. She was exposed to the Study Skills Tools five times and the Dictionary Tools two times during whole class instruction during the first week. She did, however, access the Internet three times on her own and with the teacher one time.

Terry’s pattern of TTS software use does not resemble the overall HG configuration (see Figure 10). Her pattern is a boomerang shape with depressed Average Reading Minutes. The categories that overlap completely with the HG patterns of TTS use are the Average Reading Tools and the Average Internet Tool.

Figure 10. Terry’s pattern of TTS use compared to the average HG pattern of TTS use.
**MG students’ patterns.** John, Tren, Cameron, and Kim’s cases were selected as “typical” MG students representing four different classes. Each of their TTS software use is described in depth. Using a radar chart, each of their patterns of TTS use is mapped onto the average MG TTS usage pattern to visually examine the differences and similarities.

**John.** John is an Asian male student who responded that he speaks English and another language at home. He reported that he did not have an IEP or a Section 504 Plan. John used the TTS software in his ELL Language Arts class. His Total Comprehension GLE changed from 6.1 GLE to 6.9 GLE in one semester.

John used the TTS independently for six consecutive weeks for 517 minutes averaging 86.2 minutes per week. His usage ranged from 15 minutes to 204 minutes each week. He used the reading feature whenever he logged on, so the Reading Minutes was the same as his Total Minutes. John used the Reading Tools 133 times in six weeks. His Reading Tools use varied from week to week ranging from zero to 60. The TTS log indicated that when he did use the Reading Tools, he used the tools for adjusting the reading speed and changing the voice of the TTS reader. He also used other Reading Tools such as changing the reading unit and the mode. In addition, on average, he used the Dictionary Tools 3.7 times per week, a total of 22 times in six weeks. Although John was consistent in using the Reading Tools and Dictionary Tools, he did not use the Study Skills Tools or the Internet Tool.

Figure 11 shows John’s pattern of the TTS software use. In comparing to the average MG pattern, his pattern is visually dissimilar with a longer Average Reading Minutes. However, upon closer examination, there is a significant overlap between the Average Total Minutes and the Average Dictionary Tools use.
Figure 11. John’s pattern of TTS use compared to the average MG pattern of TTS use.

_Tren._ Tren is an Asian female student who reported that she speaks only English at home. She answered that she did not have a disability or a Section 504 Plan. She used the TTS software in her World History class. Tren’s Total Comprehension GLE gain was 0.4 GLE changing from 3.8 GLE to 4.2 GLE in one semester.

Tren used the TTS software independently for 10 consecutive weeks for a total of 726 minutes, averaging at 72.6 minutes per week. Her usage ranged from 24 minutes to 112.8 minutes per week. She used the reading feature whenever she logged on, so the Average Reading Minutes was the same as her Average Total Minutes. The TTS log showed that while reading, she accessed the Reading Tools on average 14.8 times per week. The main Reading Tools used consistently was changing the reading speed. Although Tren used the Study Skills Tools on average 0.8 times per week, she actually explored the Tools only during her first week; she did not use the Study Skills Tools otherwise. She used the Dictionary Tools a total of six times during the first five weeks. After the first five weeks, she did not use the Dictionary Tools.
Figure 12 shows Tren’s TTS software pattern. Her pattern of TTS software use does not resemble the average MG pattern of the TTS software use. Unlike the average MG pattern, Tren’s pattern shows minimal Tools usage and long average reading minutes.

![Figure 12. Tren’s pattern of TTS use compared to the average MG pattern of TTS use.](image)

**Cameron.** Cameron is a Filipino male student who reported that he speaks Ilokano at home. He responded that he did not have an IEP or a Section 504 Plan. Cameron used the TTS software during his English class. After the TTS software intervention, Cameron’s Total GLE changed from 5.8 GLE to 6.4 GLE. When examining his TTS log, he used the TTS software in a total of five weeks, although he only used it independently for one week. Most of the five weeks reflected teacher-directed use. The total minutes use was 339 minutes with an average of 67.8 minutes. During that time, 247 minutes were used for reading, averaging at 49.4 minutes. On average, Reading Tools were used 34.2 times per week, Study Skills Tools were accessed 15.2 times per week, and the Dictionary Tools were used 3.6 times per week. Over the five weeks,
the TTS software was used to access the Internet one time. When Cameron used the Reading Tools on his own, he used the tools to adjust the speed and the voice.

Figure 13 shows Cameron’s TTS software pattern and the average MG pattern of TTS software use. Cameron’s average Tools usage overlaps with the average MG Tools usage on all three categories (Reading Tools, Study Skills Tools and Dictionary Tools). Although Cameron had a shorter Average Total Minutes in comparison to the MG pattern, he had a longer Average Reading Minutes. The ratio of average Total Minutes to Average Reading Minutes is approximately 7:5 for Cameron whereas it is approximately 3:1 for the MG.

Figure 13. Cameron’s pattern of TTS use compared to the average MG pattern of TTS use.

**Kim.** Kim is a female student who reported her ethnicity as Japanese Chinese. She answered that she had an IEP for her LD. She responded that she spoke only English at home. She used the TTS software in her Physical Science class. She used the TTS software for nine
weeks totaling 572 minutes, averaging 63.6 minutes per week. In one semester, Kim’s Total Comprehension GLE changed from 4.8 GLE to 5.5 GLE.

Of the nine weeks, Kim used the software for six weeks on her own. Her teacher used the TTS with the class for the entire nine weeks. Although the software was used for nine weeks, the sustained reading was short. Therefore, on average, the reading duration was 5.8 minutes per week. Meanwhile, both Kim and her teacher used the Reading Tools consistently and accessed the tools on average 32.1 times especially for changing the speed of the reading. Study Skills Tools, Dictionary Tools and the Internet Tool were only used during the first week.

Figure 14 shows Kim’s pattern of TTS software use compared to the average MG pattern of use. The two are dissimilar in configuration. Kim’s pattern of TTS software has a boomerang shape with a depressed Average Reading Minutes. The category that overlaps completely with Kim’s pattern to the average MG pattern is the Average Reading Tools. There is no other similarity between Kim’s pattern to that of the average MG pattern.

![Figure 14. Kim’s pattern of TTS use compared to the average MG pattern of TTS use.](image-url)
NG Students’ Patterns. Tom, Hank, Nobu, and Vilma’s cases were examined as the “typical” NG students representing four different subject areas. Each of their TTS software use is described in depth. Using a radar chart, each of their patterns of TTS use is mapped onto the average NG TTS usage pattern to visually examine differences and similarities.

Tom. Tom is a Pacific Islander who reported that he speaks English and his native language at home. He responded as not having an IEP or a Section 504 Plan. Tom’s Total Comprehension GLE was a negative change from 4.4 GLE to 4.0 GLE in one semester.

Tom used the TTS in his ELL Language Arts class independently for five weeks for 517 minutes averaging 103.4 minutes per week. He used the reading feature whenever he logged on, so the Average Reading Minutes were the same as his Average Total Minutes. The TTS log showed that while on the TTS software, he used the Reading Tools 15.2 times per week. The main Reading Tool he used was a tool to adjust the speed of reading. In addition, the log indicated that each time he logged on, he utilized the Dictionary Tools. Over the five weeks, he used the Dictionary Tools nine times. He did not use the Study Skills Tools or access the Internet with the TTS software.

Figure 15 shows Tom’s pattern of TTS software use. Tom’s overall pattern is dissimilar to the average NG pattern. Of the six categories, Tom’s pattern and the average NG pattern overlaps on Average Total Minutes and Average Dictionary Tools.
Figure 15. Tom’s pattern of TTS use compared to the average NG pattern of TTS use.

**Hank.** Hank is an Asian male student who responded that he did not have an IEP or a Section 504 Plan. He spoke English at home. He used the TTS software in his English class. Hank’s Total Comprehension GLE changed negatively from 6.7 to 6.4 GLE.

Hank used the TTS software for five weeks totaling 567 minutes, averaging 113.4 minutes per week. During this time, on average, his Average Reading Minutes was 93.4 minutes per week. He used the Reading Tools 54.6 times per week. From the log, Hank used the a Reading Tool to change the speed, but he also used a tool to change the voice and occasionally adjusted to read the text silently while the TTS software highlighted the words. Hank also utilized the Study Skills Tools to highlight and annotate. He created “sticky notes” while using the software. In total, he used the Study Skills Tools 86 times in five weeks, averaging 17.2 times per week. Although the use of his Dictionary was mainly by the teacher directed use, he also used the Dictionary Tools independently to look up words. Over the five weeks, he used the Dictionary Tools 21 times, averaging 4.2 times. However, Hank only used the Internet one time.
Figure 16 compares Hank’s pattern of TTS software use with the average NG pattern of use. Hank’s pattern does not resemble the average NG pattern. The similarities are seen with the use of the Dictionary Tools and the Study Skills Tools.

Figure 16. Hank’s pattern of TTS use compared to the average NG pattern of TTS use.

**Nobu.** Nobu is a male student with an IEP. He indicated he has a LD. He reported himself as a mixed ethnicity and that he spoke English only at home. His Total Comprehension GLE changed negatively from 2.6 GLE to 2.4 GLE.

Nobu used the TTS independently for nine weeks for 369 minutes averaging 41.1 minutes per week. His minutes of usage was consistent over time. The TTS log showed that he used the Reading feature whenever he logged on, so the Reading minutes was the same as his Total minutes. While using the TTS software, he accessed the Reading Tools on average 26.7 times per week, but his Reading Tools use was more frequent during the first five weeks than during the latter four weeks. Mainly, the Reading Tools he used were to adjust the speed of reading, but he explored reading silently and changing the voice of the reader. His log showed the he used
the Study Skills Tools 17 times during the nine weeks. With close examination of the log, he used the Study Skills Tools 10 times when he first used the software although he did periodically continue to use the Study Skills Tools. He only used the Dictionary Tools two times and logged onto the Internet one time.

Nobu’s pattern of TTS software use is shown in Figure 17. His overall pattern has a different configuration than the average NG pattern of TTS software use. None of the categories overlaps completely with the NG pattern.

![Figure 17. Nobu’s pattern of TTS use compared to the average NG pattern of TTS use.](image)

Vilma. Vilma is a female student who reported her ethnicity as Hawaiian and Filipino. She responded that she spoke only English at home. She answered that she had an IEP or a Section 504 Plan, but she was unsure of her disability. She was in the Physical Science class.

Over one semester, Vilma’s Total Comprehension GLE negatively changed from 5.6 GLE to 5.5 GLE. She used the program for nine weeks for 483 minutes total. Of the nine weeks, she used the program independently for four weeks. Overall, her Average Reading
Minutes was only 7.2 minutes per week. However, Reading Tools were used frequently within that time. The TTS log indicated that on average, she accessed the Reading Tools 30.7 times per week. The main Reading Tools she used was a tool for adjusting the speed of reading. She was exposed to the other tools during teacher directed sessions when she was first introduced to the program. Therefore, Vilma did not use these other tools on her own.

Figure 18 shows Vilma’s pattern of TTS software use compared to the average NG pattern of use. Vilma’s pattern is a boomerang shape. The category that almost overlaps between Vilma’s pattern and the average NG pattern is the Average Reading Tools. There is no other similarity between her pattern of TTS use to that of the average NG pattern.

Cross Case Conclusions

HG students. The summary radar chart shows that the four cases of HG students all had different patterns of TTS software use (Figure 19). In addition, none of their patterns matched the average HG pattern of TTS software use.
Figure 19. Four HG case TTS pattern of use compared to the average HG pattern of use.

**MG students.** The summary radar chart (Figure 20) shows that, John and Tren had similar patterns of use. Cameron and Kim, however, had different patterns than John and Tren. In addition, none of the four cases had patterns that matched the average MG pattern of TTS software use. However, three of the four cases had a significant overlap with the use of the Dictionary Tools.
NG students. The summary radar chart shows that the NG students’ cases all had different patterns of TTS software use (Figure 21). None of their patterns matched the average NG pattern of TTS software use.
To further examine the patterns of the selected cases by reading gain groups, the average of the four cases from each of the groups was calculated. These average patterns of the selected cases were compared (see Figure 22). The average patterns of the four cases for each of the reading gain groups were similar. The three average patterns overlapped with one another on all categories except for Average Reading Tools. On average, selected case HG students used the Reading Tools more than the selected cases of MG or the NG students.

![Figure 22](image)

*Figure 22. The average patterns of the selected cases by reading gain groups depicting.*

**Findings of Research Question 2**

Why did the students’ patterns of TTS software use (i.e., duration, frequency, and tools) differ by reading gains?

a. Did the teachers’ implementation impact the students’ patterns of TTS software use by reading gains?

b. Did students’ attitudes and perceptions towards the TTS software intervention impact their patterns of TTS software use by reading gains?
Although there were noticeable differences in the average patterns of the TTS software use between the HG compared to the MG and NG as a whole group, within and cross case analyses of the 12 cases by their reading gain groups did not support that there were distinctive patterns that were unique to each reading gain group. Therefore, for Research Question 2, I investigated why the patterns of TTS software differences were not as distinctive by reading gain groups.

**Within Class Analysis**

Participating students’ classes were organized into 5 major categories: (1) ELL, (2) Language Arts, (3) History, (4) Science, and (5) Other. ELL included ELL Language Arts and the elective course for English for Speakers of Other Languages (ESOL). English included English, Language Arts, and Reading courses. History included World History and US History courses. Science included Marine Science, Physical Science, Biology and Math. All of the other courses such as Communications, mixed math and reading, and business were classified as “other.” Table 12 summarizes the number of students in each of the class type.

**Mr. Ota’s ELL class.** Jesse, John and Tom used the TTS software in Mr. Ota’s ELL Language Arts class during Spring 2013. The class was comprised of 16 students, was 75 minutes in duration and met three times a week. The intervention period with Mr. Ota’s class occurred over a period of two and half months. Mr. Ota had participated in the Steppingstones Study in the previous semester as a comparison group, but Spring 2013 was the first semester that he participated in the intervention condition.

**Independent use.** In Mr. Ota’s class, the students used the software independently for six weeks. He had the students complete a one page worksheet each week using the TTS software.
Table 12

*Number of Students by Reading Gain Groups by Class Type*

<table>
<thead>
<tr>
<th>Class Type</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ELL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NG</td>
<td>15</td>
<td>39.5</td>
</tr>
<tr>
<td>MG</td>
<td>16</td>
<td>42.1</td>
</tr>
<tr>
<td>HG</td>
<td>7</td>
<td>18.4</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>History</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NG</td>
<td>10</td>
<td>40.0</td>
</tr>
<tr>
<td>MG</td>
<td>6</td>
<td>24.0</td>
</tr>
<tr>
<td>HG</td>
<td>9</td>
<td>36.0</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>English</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NG</td>
<td>25</td>
<td>44.6</td>
</tr>
<tr>
<td>MG</td>
<td>12</td>
<td>21.4</td>
</tr>
<tr>
<td>HG</td>
<td>19</td>
<td>33.9</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NG</td>
<td>12</td>
<td>48.0</td>
</tr>
<tr>
<td>MG</td>
<td>9</td>
<td>36.0</td>
</tr>
<tr>
<td>HG</td>
<td>4</td>
<td>16.0</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NG</td>
<td>7</td>
<td>38.9</td>
</tr>
<tr>
<td>MG</td>
<td>7</td>
<td>38.9</td>
</tr>
<tr>
<td>HG</td>
<td>4</td>
<td>22.2</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>100.0</td>
</tr>
</tbody>
</table>
**Benefits of TTS.** Mr. Ota commented that the benefits of the TTS software use were that the “students seemed to have helpful in finding the definitions of words easily.” He also noted that students were annotating the reading passages and [this] made it easy for the students to “copy words to blank documents.” Mr. Ota found the program to be very user friendly and would have liked the students to use it with a short story book rather than a one-page reading assignment. After the intervention, he definitely thought that the program helped students with reading comprehension and to improve their vocabulary.

**Similarities in patterns.** After the TTS intervention, Jesse, John and Tom had different reading gains, but they had similar patterns of TTS software use in Mr. Ota’s class as can be seen in Figure 23. They all had 1:1 ratio of Average Total Minutes to Average Reading Minutes, zero use of the Study Skills Tools and zero use of the Internet Tool.

![Figure 23. Tom, John and Jesse’s patterns of TTS use in Mr. Ota’s class.](image)

**Ms. Ruby and Mr. Archer’s English class.** Mia, Cameron and Hank were in Ms. Ruby and Mr. Archer’s English class. Ms. Ruby was the special education teacher co-teaching the
class with Mr. Archer, who was the English teacher. The class met for 90 minutes each day, five times a week. Three of their periods participated in the study with 23, 22, and 27 students in each of the classes. Mia, Cameron and Hank were all from the same period. Aside from the TTS software, Achieve 3000, an online literacy program, was used in the class.

**Whole group instruction.** Ms. Ruby reported that the class used the program for 45 minutes a week while reading *Of Mice and Men* and completing a research paper. They implemented the program as a whole class instruction but students also had opportunities to use the software independently for the five to six weeks. During the whole group instruction, Mr. Archer and Ms. Ruby used the projector to connect the TTS software and read sections of the book together. Meanwhile, the teachers, with their students, also highlighted and extracted notes that could be used in their individual research papers. They did not use the program to access the Web. Although the project did not introduce the writing features to the teachers or students, the teachers reported that they occasionally utilized the writing template.

**Benefits of TTS.** After the intervention, Ms. Ruby responded that program was highly relevant in integrating reading activity in their English class. She thought the program was user friendly and she “liked the tools such as highlighting and extracting quotes from material.” She would definitely use the program again and would like to try the program to do research on the Web and create vocabulary list.

**Similarities in patterns.** After the TTS intervention, Mia, Cameron and Hank had different reading gains, but they had similar patterns of TTS software use. Their patterns were not overlapping, but the configuration based on the six categories were similar except for Mia’s use of Reading Tools. Cameron and Hank’s patterns were identical in shape but proportionately,
Hank’s usage was longer and more frequent on all categories. They all used the Dictionary Tools, Study Skills Tools and Reading Skills Tools.

Figure 24. Hank, Cameron and Mia’s patterns of TTS use in Mr. Archer’s class.

**Mr. Raven’s History class.** Aiden, Tren and Nobu used the TTS software in Mr. Raven’s World History class in Spring 2012. His class was typically 120 minutes long and met three times a week. He had been teaching high school students for eight years. Three of his classes participated in the study. There were approximately 26 students in each class. All three participants were enrolled in the same class period.

**Independent use.** In Mr. Raven’s class, the students used the software independently for 10 weeks. Mr. Raven had the students read the World History textbook and to read the Websites for their research projects and presentation. Although students used the TTS software independently, sometimes due to limited number of computers, students used the TTS software as a small group.
**Benefits of TTS.** Mr. Raven commented that the software was beneficial to struggling readers at lower reading levels. He commented that it was beneficial “especially [for] those with limited vocabulary and pronunciation difficulties.” If he were to use the TTS software again, he would “scan a larger/greater variety of material.”

After the TTS software intervention, he felt that the TTS software was user friendly. He was neutral about whether the program was relevant in integrating reading activity in his class, however.

**Similarities in patterns.** Aiden and Nobu’s patterns were almost identical to each other for all six categories (Figure 25). Tren’s pattern was not similar to Aiden’s or Nobu’s patterns.

![Figure 25. Aiden, Tren and Nobu’s patterns of TTS use in Mr. Raven’s class.](image)

**Mr. Lime’s Physical Science class.** Terry, Kim, and Vilma used the TTS software in Mr. Lime’s Physical Science class during Fall 2011. The class was a special education resource science class; therefore, all of the students who were enrolled in the class had an IEP. Mr. Lime used the TTS software intervention with three class periods. There were approximately eight
to 11 students in class. He had a teacher’s aide in the class who assisted with scanning the materials to be used. One class period was approximately 37 minutes long. He indicated that he spent about 21-30 minutes on reading activity during each class period.

**Whole class instruction.** In Mr. Lime’s class, the students used the TTS software with the Physical Science textbook chapter assignments and current events articles on the Web. Mr. Lime set up the classroom to use the TTS software for whole group instruction and for the students to use independently. Each week for 10 weeks, Mr. Lime and his class read current event articles as a whole group. He scanned current event articles and projected the articles on to the screen and had the TTS software read the article. As the TTS software read the article, Mr. Lime demonstrated the use of the software tools. There were instances, however, where Mr. Lime nor the students could log-on to Kurzweil program due to inconsistent wireless connectivity in the classroom.

**Benefits of TTS.** Mr. Lime commented that he liked the TTS software intervention because the students were able to use the computers to read and were able to select reading speed. After the TTS software intervention, he felt that the use of the TTS software would likely help improve students’ vocabulary and reading comprehension. He also agreed that the program was user friendly and relevant in integrating reading activity in his class.

**Similarities in patterns.** Terry, Kim, and Vilma’s patterns of TTS software use were almost identical and overlapping with one another. Visually, the three patterns had boomerang-shaped TTS usage pattern and had overlapping Average Reading Tools usage. The main use of the TTS software was in the Reading Tools. Very little time was actually spent on the reading.
Cross Case Conclusions

a. Did the teachers’ implementation impact the students’ patterns of TTS software use?

The patterns of TTS software use were similar amongst those students in the same class/teacher; however, they differed from their respective overall reading gain groups. In all cases, students within the same class used the TTS software for about the same number of weeks unless the student was absent or there was a technical issue with the computer or the TTS software. Moreover, students used the software for specific tasks assigned by the teachers regardless of whether the students used the software independently or during whole class instruction. In addition, none of the students used the software outside of their classes as the program was not installed at home or in other publicly available locations.

**Teacher delivery and tasks.** Each of the teachers had a specific time frame and tasks when they implemented the TTS software. Mr. Lime used the TTS software during whole class instruction using a projector. Mr. Lime used the program with the students consistently over 10
weeks and the students had a short time to explore independently. The students had the specific task of answering questions from current events after reading the events as a whole class. Terry (HG), Kim (MG) and Vilma’s (NG) patterns were almost identical to each other, and to the average pattern of TTS software use for Mr. Lime’s class as a whole except for the slight duration difference when compared to the average total minutes (See Figure 27).

![Figure 27. Terry, Kim and Vilma’s patterns of TTS use compared to Mr. Lime’s class average pattern of TTS use.](image)

Ms. Ruby/Mr. Archer’s class also incorporated whole-class instruction, and the patterns were similar in shape but not overlapping like Mr. Lime’s class. There were differences in the duration and frequency amongst the three students’ cases. However, the average class pattern also had a similar configuration (See Figure 28). In Ms. Ruby/Mr. Archer’s class, after using the program as a whole instruction, students continued to work on their independent research paper, which was different from Mr. Lime’s more prescribed assignment/task that students completed with the TTS software.
Figure 28. Cameron, Mia and Hank’s patterns of TTS use compared to Ms. Ruby/Mr. Archer’s class average pattern of TTS use.

The influence of the assigned task on the patterns of use is also evident when examining the patterns of Mr. Ota’s ELL and Mr. Raven’s student cases. There was no whole class use of the TTS software in Mr. Ota’s ELL and Mr. Raven’s World History classes. Students used the TTS software independently, but with specific assigned tasks. Mr. Ota had the students use the software with a one page reading assignment. Mr. Raven used the TTS software with the World History textbook, for reading the Web and also for preparing for presentations. Even though there was no whole class instruction by the teacher using the TTS software, the patterns of the TTS use were still similar for Jesse, John and Tom in Mr. Ota’s class and for Tren and Nobu in Mr. Raven’s class with their respective average class patterns (Figures 29 & 30).
Figure 29. Jesse, John, and Tom’s patterns of TTS use compared to Mr. Ota’s class average pattern of TTS software use.

Figure 30. Aiden, Tren, and Nobu’s patterns of TTS use compared to Mr. Raven’s class average pattern of TTS software use.
Teacher Experience in Implementation

Teacher experience in using the TTS software varied. Mr. Raven had participated in two other semesters of using the Steppingstones intervention prior to teaching Aiden, Tren and Nobu. Mr. Lime was participating for the second semester; however, his first semester of participation utilized a network version of Kurzweil 3000 v. 12. Mr. Ota, Mr. Archer and Ms. Ruby were participating for the first time in the intervention group.

Students’ Attitudes and Perceptions

Select questions from the students’ pre-post surveys provided information about students’ attitudes and perceptions towards the TTS software intervention. The select questions are listed in Table 13.

Table 13

Select Questions From Surveys Used for Analysis

<table>
<thead>
<tr>
<th>Survey</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre &amp; Post survey</td>
<td>1. Do you think the use of text-to-speech computer reading software help improve vocabulary?</td>
</tr>
<tr>
<td>Pre &amp; Post survey</td>
<td>2. Do you think the use of text-to-speech computer reading software help improve comprehension?</td>
</tr>
<tr>
<td>Post Survey</td>
<td>3. What did you like the most about using the Kurzweil software?</td>
</tr>
<tr>
<td>Post Survey</td>
<td>4. How did the Kurzweil software help you with your classwork or assignments?</td>
</tr>
<tr>
<td>Post Survey</td>
<td>5. What did you like the least about using the Kurzweil software?</td>
</tr>
<tr>
<td>Post Survey</td>
<td>6. Did the Kurzweil software help you understand the reading better?</td>
</tr>
<tr>
<td>Post Survey</td>
<td>7. To what extend did you find the Kurzweil software to be a user-friendly reading tool?</td>
</tr>
<tr>
<td>Post Survey</td>
<td>8. Would you use the Kurzweil software again?</td>
</tr>
</tbody>
</table>
Within HG students.

**Jesse.** Prior to the intervention, Jesse was neutral about whether the TTS software would help improve his vocabulary and comprehension. After the intervention, he was still neutral about its helpfulness in improving his vocabulary, but he thought that it was unlikely to help improve comprehension. He did not respond to item #2 “Do you think the use of TTS computer reading software help improve comprehension?” However, he did find the program to be useful. He wrote “it helped me with picking out key points.” He did not comment about what he liked the most about the software, but he commented what he least liked about the TTS software: He did not like that it did not read fluently. Jesse was neutral about whether he would use the program again.

**Mia.** Prior to the TTS software intervention, Mia thought that the software would definitely help her improve both her vocabulary and comprehension. After the intervention, she was neutral about whether the use of the TTS software would support her in those areas, but she agreed that the software helped her understand the reading better. Mia strongly agreed that the software was user friendly and from her comment as well as her usage, it was evident that she wished to continue using the software. She stated, “I’ve only got to use it once a week” and her usage increased over time. When asked about whether she would use the software again, she indicated that she definitely would use it again.

**Aiden.** Before intervention, Aiden was neutral about whether the use of the TTS software would help improve his vocabulary and comprehension. After the intervention, he thought that it was unlikely that the TTS software would help improve his vocabulary. He remained neutral about whether it would help improve comprehension. He also was neutral about whether the software helped him understand the reading better. Although he was neutral
about its helpfulness, Aiden stated the software helped him finish his work “a bit faster.” He liked how the software “just read” to him. He was neutral about whether he would use the software again.

**Terry.** Prior to using the TTS software, Terry thought that the TTS would definitely help in improving her vocabulary and would likely support her reading comprehension. After using the TTS software, she responded that the TTS software use definitely helped improve her vocabulary and comprehension. Terry agreed that the software helped her understand the reading better, and what she liked the most about the software was that it read to her and she was able to get through her classwork or assignments faster. She also wrote that she could understand the assignment better. She did not have anything she disliked about the software. She agreed that the software was user friendly and that she would likely use the software again.

**Within MG students.**

**John.** Prior to the intervention, John thought that the use of the TTS software would likely help improve both his vocabulary and comprehension. However, after the intervention, he was neutral that the TTS software would help improve his vocabulary and comprehension. He was also neutral about whether the software helped him understand the reading better. Aligned with his response about what he least liked about the TTS software, he commented, “it’s hard to understand the reader.” What John liked the most about the TTS software was that “it provided dictionary” and “it help[ed] me to find the definition for the word I don’t know.” He agreed that the software was user friendly and felt that he would likely use the software again.

**Tren.** Prior to intervention, Tren thought that the use of the TTS software would likely improve vocabulary but was neutral about its helpfulness to improve comprehension. After the intervention, her attitude remained the same about its usefulness in improving her vocabulary
and comprehension. However, she did agree that the software helped her understand the reading better and commented that the TTS software “help[ed] me because so I can understand more.” She liked how the TTS software read to her and helped her understand. At the same time, she did not like the voice of the software. Tren was neutral about the software’s user friendliness, but still responded that she would definitely use the software again.

**Cameron.** Prior to the intervention, Cameron thought that the TTS software would likely help improve her vocabulary but was unlikely to help improve his comprehension. After the intervention, he thought that TTS software was likely to help improve both her vocabulary and reading comprehension, and he agreed that the software helped him understand the reading better. Cameron commented that he liked how it read to him and gave him the definitions. He did not like the voice of the computer, however. Cameron agreed that the software was user friendly and that he would definitely use the software again.

**Kim.** Prior to the intervention, Kim was neutral about whether the TTS software would help improve vocabulary and comprehension. After the intervention, she was still neutral about whether the TTS software would help improve her vocabulary and comprehension. However, she agreed that the software helped her understand the reading better and she liked that she did not have to “read it to myself because the computer reads the words to you.” She also commented that with the TTS software, she could “find answers much faster.” She did not like the fact that the software had difficulty with signing in. However, she still agreed that the software was user friendly and indicated that she would likely use the software again.

**Within NG students.**

**Tom.** Prior to the intervention, Tom was neutral about whether the software would help improve his reading vocabulary and comprehension. After the intervention, he thought that it
was unlikely that the use of the TTS software would help improve his vocabulary and reading comprehension. Moreover, he strongly disagreed that the software helped him understand the reading better. He commented that he did not like anything about the software and that it was “irritating” because he did not know what the software was saying. He wrote that he would rather read a book instead of listening. Tom disagreed that the TTS software was user friendly. He “liked nothing” about the TTS software and he responded that he would not use the TTS software again.

Hank. Prior to the intervention, Hank thought that the TTS software would likely help improve both his vocabulary and comprehension. After the intervention, he became neutral about whether the TTS software would help improve his vocabulary and comprehension. Mainly, he liked the software because he did not have to read as it read to him. He found it helpful that it read to him because he described himself as “lazy to read.” He also agreed that the software helped him understand better. As well as liking the TTS software reading to him, Hank also commented that he did not like “the voices talking, sometimes you can’t understand.” He agreed that the software was user friendly and that he would definitely use it again.

Nobu. Before the intervention, Nobu was neutral about whether the TTS software would help improve his vocabulary and comprehension. After the intervention, he thought that it was likely that the TTS software would help improve his vocabulary but was neutral about it with regard to comprehension. He was also neutral about whether the software helped him understand the reading better. What he liked the most about the program was simply logging in. He did not feel that it helped him with classwork or assignments and he did not like the voice. He was neutral about the software’s user friendliness and he responded that it was unlikely that he would use the software again.
**Vilma.** Prior to the intervention, Vilma thought that the software would likely help improve her vocabulary and reading comprehension. After the intervention, she still thought that the software would likely help her improve vocabulary, but she was neutral about comprehension. She was also neutral about whether the TTS software helped her understand reading better. She commented that she liked how the software read the story and it helped her pronounce the words she could not say. However, when asked what she least liked about the TTS software, she wrote “I have a hard time getting it in my head.” Vilma was neutral about the software’s user friendliness and responded that it was unlikely that she would use the software again.

**Cross Case Conclusions**

In comparing the perceptions and attitudes of students, there were group differences by gains as well as by teacher/class. A few trends and themes emerged. The selected students’ coded comments are in Appendix H.

**It reads to you.** Students commented about what they liked the most about TTS. Of the 12 selected cases, seven students commented that what they liked the most about TTS software was that it read to them. Three of the four MG students all commented that they like this feature the most and they also responded to the question that using the TTS software helped them understand better. Only two of the four students liked the reading feature the most from the HG and NG groups. In addition, only one of the four students from each of the HG and NG groups who liked the reading feature also responded that they understood better using the TTS software. None of Mr. Ota’s ELL students (Jesse, John and Tom) commented about liking the TTS software reading to them. In fact Jesse and Tom did not respond to this question. John wrote that “it provided dictionary.”
**Purposeful usage.** When asked about how the TTS software helped with their classwork or assignments, HG and MG students commented about specific aspects of how the TTS software was useful in helping them to complete or to do the classwork. Terry, Aiden and Kim all commented that they could complete the assigned classwork “faster.” Jesse answered that the TTS software helped him with “picking out key points.” John and Cameron found the software to be helpful in looking up the definitions. John said that he could “find the definition for the word I don’t know.” Terry, Mia and Tren found the software to be helpful with comprehension of their work. They relayed that from using the software in doing classwork, they could “understand” more. On the contrary, the NG students’ comments were not so specific as to how TTS software was helpful in completing the classwork. Vilma’s response was more specific than other NG students and she wrote that “by reading the story, it helped me pronounce the words I couldn’t say.” However, she did not expand on whether being able to pronounce the words was helping her with comprehension or completing tasks. Mia from the HG group also found that the TTS was helpful for her to pronounce the words she could not say, but she also commented that it helped her “understand what they are.” For Tom, he said that nothing was helpful whereas for Nobu, it helped “so much.” Similarly, Hank commented that it helped him a lot because it read to him because he was lazy to read by himself, but he did not comment on how that helped him.

**Ability to understand from listening.** When students were asked to comment about what they least liked about the software, two of the HG students did not have anything that they disliked about the TTS software. In fact, Mia wanted to use the software more and commented, “I’ve only got to use it once a week.” The other HG students simply commented about some function of the TTS software that did not work smoothly. Aiden mentioned, “sometimes it goes
weird when we use the web.” Jesse said he least liked “how it doesn’t read fluently.” On the other hand, all participants from the MG and NG groups commented that they disliked the TTS software’s voice, and also had difficulty understanding from “listening.” Only Kim from MG did not comment about disliking the voice or not being able to understand the reader. Her comment was similar to the HG students and focused on the functionality of the TTS software itself. The feature that she least liked about the software was that it “sometimes doesn’t sign in.” For the rest of the MG and NG students, the voice or listening was an issue regardless of whether they liked the TTS software reading to them.

John commented that it was “hard to understand” the TTS software reader. Similarly, Vilma said that although she liked how the program “read the story and helped her pronounce the words she could not say,” she wrote, “I had a hard time getting it in my head.” Hank also commented that he least liked “the voices talking” and said, “sometimes you can’t understand.” Tom noted a similar experience. Tom commented that he would rather read a book instead of “listening” and that the program was “irritating” as he did not know what the software was saying. For Tren and Nobu, although they did not comment about the difficulty in understanding from listening, they responded that they did not like the TTS software’s “voice.”

**Post intervention attitudes.** Figure 31 combines the students’ responses on post intervention attitudes and perceptions of TTS use on improving students’ reading vocabulary and comprehension. The figure is color coded to visually display the trends within and across groups.

More MG students overall had positive attitudes towards the TTS software intervention. Prior to the intervention, all but one MG student, Kim, thought that the TTS software would likely help improve vocabulary. After the intervention, Tren and Cameron thought that the TTS
software would help improve vocabulary but the other two, John and Kim were neutral. All MG students responded they were likely to or would definitely use the software again. Aside from Tren, they also all agreed that the TTS software was user friendly. This was different for HG and NG students.

<table>
<thead>
<tr>
<th>Case</th>
<th>Want to use again?</th>
<th>User friendly?</th>
<th>Understand better?</th>
<th>Pre improve vocab</th>
<th>Pre improve comp</th>
<th>Post improve vocab</th>
<th>Post improve comp</th>
</tr>
</thead>
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<tr>
<td>Jesse</td>
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<td>No Answer</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Mia</td>
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<td>Strongly Agree</td>
<td>Agree</td>
<td>Definitely</td>
<td>Definitely</td>
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<td>Neutral</td>
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<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Unlikely</td>
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</tr>
<tr>
<td>Terry</td>
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<td>Agree</td>
<td>Agree</td>
<td>Likely</td>
<td>Unlikely</td>
<td>Likely</td>
<td>Likely</td>
</tr>
<tr>
<td>John</td>
<td>Likely</td>
<td>Agree</td>
<td>Neutral</td>
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<td>Likely</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Cam.</td>
<td>Definitely</td>
<td>Agree</td>
<td>Agree</td>
<td>Likely</td>
<td>Unlikely</td>
<td>Likely</td>
<td>Likely</td>
</tr>
<tr>
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<td>Definitely</td>
<td>Neutral</td>
<td>Agree</td>
<td>Likely</td>
<td>Neutral</td>
<td>Likely</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>Disagree</td>
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<td>Likely</td>
<td>Likely</td>
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</tr>
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<td>Likely</td>
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<td>Neutral</td>
</tr>
</tbody>
</table>

*Figure 31* Responses to select questions from surveys. The responses are color coded to illustrate the trends. Orange color boxes are positive responses; the yellow color boxes are negative responses; gray boxes are neutral; and white boxes are no response.

The responses were mixed for the HG group. Mia and Terry both thought that the TTS software would help improve vocabulary and comprehension before the intervention. After the intervention, they agreed that the TTS software was user friendly and wanted to use the TTS software again. Jesse and Aiden both were neutral about whether the TTS software would help improve vocabulary and comprehension before the intervention. In fact, after the intervention, Jesse thought it was unlikely that the TTS software would improve comprehension and Aiden thought it was unlikely that the TTS software would improve vocabulary. They were neutral
about wanting to use the software again. Jesse did not comment about the software’s user friendliness and Aiden was neutral.

For the NG students, the main difference with the other reading gain groups was that except for Hank, they did not find the TTS software to be user friendly. Moreover, Nobu and Vilma responded that it was unlikely that they would want to use the software again even though after the intervention Nobu and Vilma responded that they thought that the TTS software would help improve their vocabulary. Tom responded that he would never want to use the software again.

**Perceptions of TTS use.** Even though HG and MG students made significant gains in reading comprehension, only two of the students thought that the use of the TTS software improved reading comprehension where as prior to the intervention, five of them responded that the TTS software would help improve reading comprehension. This negative trend is the same for vocabulary. Seven students initially responded that the TTS software use would help improve vocabulary, but post intervention, only five students responded that the TTS software would help improve vocabulary.
CHAPTER 5
DISCUSSION

The purpose of this embedded multiple case study was to investigate how the TTS intervention was effective in improving reading comprehension of adolescent struggling readers by analyzing the patterns of TTS software tools use by students who made HG, MG, and NG in reading comprehension.

Twelve cases, four cases from each of the HG, MG, and NG, were examined. In this discussion section, additional cases are included as literal replications to the findings of Research Question 1 of the study. Literal replication can corroborate the findings about the patterns of TTS software use by predicting similar results. Then, I expand on the discussion of Research Question 2 by examining the results at the teacher/class level and student level. I conclude this section with limitations of the study, recommendations for how TTS software intervention can be utilized within the secondary education classes, and implications for future research.

Research Question 1

Literal Replications

Although there was a statistically significant difference between the MG and HG reading gain groups with regard to the Average Reading Minutes of the TTS software, this difference was not observed across the twelve cases. This was unexpected, as having a longer reading time would seem to correlate with an improved reading outcome based on the literature on struggling readers. Struggling readers spend less time reading compared to average readers, which lead to the reading gap (Wren, 2002) because they are less exposure to various types of text and vocabulary. In other words, with the TTS software use, the students’ reading outcomes could have improved due to exposure to more text. However, the results of the case study showed that
when comparing the students’ patterns of TTS software use by reading gains, their Average Reading Minutes were similar across the reading gain groups. Moreover, no distinctive pattern of TTS software use emerged that corresponded to the specific reading gain group. Rather, each individual case pattern of the TTS software use was unique when compared to their respective overall gain groups. When the cases were analyzed across reading gains at the teacher/class level, unique patterns of the TTS software use appeared for each teacher/class. This means students’ patterns of TTS software use were more closely associated with the classes in which they used the TTS software. Thus, when the patterns of the HG, MG and NG cases from the same classes were compared across the reading gains, these cases all had similar patterns of the TTS software use regardless of their gains. This finding suggests that overall patterns of the TTS software use were influenced or closely aligned with what was occurring at a teacher/class level rather than at an individual level. Additionally, the implication here may be that there is not a single way of using the TTS software in order to improve the reading outcomes of struggling adolescent readers.

To further examine if the teacher/class influenced the overall patterns of the TTS software use rather than the reading gains, literal replications of the results were conducted using the radar chart. If the patterns of the TTS software use were influenced by the teacher/class level, then a unique pattern for a particular teacher/class should be observed regardless of the students’ reading gains. Three additional classes were selected from the Steppingstones Study and represented using a radar chart to visually discern the patterns. For each class, the average pattern of the whole class and three student cases from different reading gain groups were included.
Figure 32. Literal replication of the finding - Ms. Hara’s US History class.

Figure 33. Literal replication of the finding - Ms. Thomas’s ELL class.
Figure 34. Literal replication of the finding- Ms. Reyes’ Biology class.

As predicted, the radar charts of Ms. Hara, Ms. Thomas and Ms. Reyes’ classes were distinctive from each other in configuration. Within their classes, however, the students’ patterns of use were relatively similar to one another with minor variations. These literal replications provide evidence that the patterns of TTS software use are teacher specific rather than content specific such as ELL or history. For instance, Ms. Thomas’ ELL students’ patterns of TTS software use were different from Mr. Ota’s ELL students’ patterns of TTS software use. In sum, the TTS software pattern of use did not differ by reading gain groups (i.e., HG, MG, and NG), but in comparing the patterns across teacher/class, a unique pattern of TTS software use emerged for each of the teacher/class.
Research Question 2 – Class/Teacher Level

Research Question 2 examined why the students’ patterns of TTS software use differed by reading gain groups. However, as found from the results of the Research Question 1, the patterns of the TTS software use did not differ by reading gains but were similar across teacher/class for the selected cases using the radar chart analysis. Why were the patterns of TTS software use similar for students within the same teachers’ classes regardless of their reading gains? One explanation for this may be because the Steppingstones Study was conducted in a natural classroom setting where the teachers implemented the TTS software intervention in their classes with minimal guidance from the researchers. The teachers received a standardized one time, 45 minutes training on the use of the TTS software and were asked to use the software for a minimum of 30 minutes per week for 10 weeks with the students. The research staff assisted the teachers by setting up the computers, trouble shooting the software or the computer, scanning their chosen materials, and providing some examples on how the TTS software could be used in a classroom. However, there was no “scripted instruction” on how or when the TTS software should be integrated into their teaching practices. Teachers had the freedom to use the TTS software in a way that they saw fit for their class. Therefore, the TTS software use was teacher-directed with teacher selected materials and spent on tasks that were determined by the teacher.

Teacher Delivery and Tasks

Within class/teacher analysis and the literal replications revealed that the students’ patterns of the TTS software use were specific to the teacher rather than the type of class (e.g., history). Moreover, the results revealed that the teachers’ implementation of the TTS software intervention had impact on the tools that the students used regardless of students’ reading gains, disability status or ELL status.
For the 11 cases, except for Tren (MG) in Mr. Raven’s class, the students’ TTS software patterns resembled their class pattern regardless of their reading gains. Interestingly, this did not seem to be influenced by how the teacher structured instruction (e.g., incorporated the TTS software as a teacher-directed whole class instruction, had the students use independently, or incorporated both methods). The results illustrating that the students’ patterns of the TTS software use were the same regardless of whole-class or independent use of the TTS software imply that it was not only the teachers’ delivery of instruction using the TTS software, but also the tasks assigned, which influenced how students used the TTS software. The teacher delivery and tasks can be categorized into four implementation styles: (1) independent TTS use for a single/short task; (2) independent TTS use for multiple/longer tasks; (3) mixture of independent and whole class instruction for a single/short task; (4) mixture of independent and whole class instruction for multiple/longer tasks.

**Independent use for a single/short task.** In Mr. Ota’s ELL class, all three cases, Jesse (HG), John (MG) and Tom (NG), had very similar patterns of use even though Mr. Ota did not use the TTS software for whole class instruction nor did he model the use of the TTS software. For approximately six weeks, on a weekly basis, Mr. Ota assigned a one-page worksheet that required students to read short passages and answer questions using the TTS software. Reflective of the assignment, Jesse, John and Tom used Dictionary Tools to look up words and answer questions. However, they all did not use the Study Skills Tools despite receiving the same training on the use of the TTS software from the research staff. One reason for their lack of Study Skills Tools use may be because the one page worksheet did not contain long passages that required them to utilize annotation tools.
Independent use for multiple/longer tasks. Similarly, Mr. Raven, in his World History class, directed students to use the TTS software independently and did not use the TTS software for whole class instruction. However, rather than having the students use the TTS software for the same task only, he had students utilize the TTS software for a few different tasks such as for completing textbook questions, developing a research paper, and preparing for a presentation. Mr. Raven’s students also were able to use the software for 10 weeks. In comparison to Mr. Ota’s students, this variability in assignment and longer period of use allowed students to explore the TTS software tools more. Aiden (HG), Tren (MG) and Nobu (NG) all used Reading Tools, Study Skills Tools, and Dictionary Tools. Aiden and Nobu also used the Internet. This variation of assignments/tasks could have led Tren to have different patterns of the TTS software use than Aiden or Nobu: Perhaps Tren was using the software more for multiple tasks. In fact, Tren used the TTS software twice as long in duration than Aiden and Nobu. Mr. Raven’s comment about the TTS software benefiting struggling readers at lower reading levels implies that he was allowing students who needed to use the software use the software more. The reason why Tren was able to use it longer may also have to do with availability of equipment in Mr. Raven’s class. Mr. Raven’s class was a full inclusion class but only limited numbers of laptop computers were available for the students to use the TTS software. Therefore, Mr. Raven probably had to make a decision about who would be able to use the software on a particular day. However, the question remains why Aiden and Nobu, despite having more flexibility in use, still had similar patterns of the TTS software use. Their pattern was also similar to the average class pattern. The implication here is that the teacher’s influence is still evident. Mr. Raven guided the students to use the TTS software for reading the textbook and answering questions, looking up information on the Internet for research, and preparing for presentations.
Mixed instruction for a single/short task. On the flip side of independent use is the whole class instruction. Mr. Lime also had a specific task for students to use the TTS software like Mr. Ota’s class, but he also demonstrated the use of the TTS tools as a whole class instruction. As previously described, he scanned current event articles and projected on to the screen and had the TTS software read the article. As the TTS software read the article, Mr. Lime demonstrated the use of the software tools. This manner of whole class instruction using the TTS software led to a very similar pattern of use by Terry (HG), Kim (MG), and Vilma (NG) even though they had some independent time. Of the nine weeks, the three students spent about half of the weeks where they used the TTS software on their own, but they did not explore the tools much on their own. Mr. Lime also did not demonstrate the use of the Study Skills Tools or the Dictionary Tools after the first two weeks. In addition, because the task students were assigned to do was short/limited, it is probable that the students did not capitalize on using the Study Skills Tools or the Dictionary Tools beyond the first two weeks. As Marino (2009) pointed out about the use of technology tools, it is important that the students know how or when to use them or the students will not be able to apply it to their learning.

Mixed instruction for a longer task – a seamless integration. Mr. Archer/Ms. Ruby’s English class had the students use the TTS software for independent research for essay writing. Each time before the TTS software intervention, the teachers used the TTS software together as a class first for the same task then they had students complete an assignment independently. They integrated the use of the TTS software for the students’ research paper on Of Mice and Men. For example, they modeled reading a section, highlighting an interesting quotation and extracting the quotation to a new document for writing the essay. This type of observational learning (Bandura, 1977) and scaffolding (Vygotsky, 1980) is very powerful in the classroom. In Mr.
Archer/Ms. Ruby’s class, students were able to learn from the teachers’ demonstrations, and carry-on with the same assigned task. This seamless integration of the TTS software use probably fostered the students in Mr. Archer/Ms. Ruby’s class to explore the Reading Tools and the Study Skills Tools on their own as well. In addition, the teachers were able to provide ample time each week for the students to utilize the TTS software because of their block scheduling. Therefore, Mia (HG), Cameron (MG), and Hank (NG), all had similar patterns of the TTS software use probably because of the whole class instruction and guidance from their teachers on the types of tools available. Additionally, teachers suggested which tools were suitable for the task of reading and working on their research paper. The differences in their duration and frequency amongst the three cases show that the students were able to utilize the software as needed unlike Mr. Lime’s or Mr. Ota’s classes where the tasks were short and in essence more constrained. Hank, on his post survey, reflected positively on this seamless integration. From the four NG cases, Hank was the only student who stated that he would definitely want to use Kurzweil again and that he agreed that the software was user friendly and helped him understand better even though he did have some trouble understanding the voice.

**Teacher Experience in Implementation**

Teachers’ delivery and tasks influenced the patterns of the students’ TTS software use, but their delivery and task choices also were influenced by their experience with the TTS software. As Diamond (2006) states, for the teachers to implement a reading intervention effectively, teachers need ample time to practice. By the time Mr. Raven was teaching Aiden, Tren and Nobu, he had already participated in two semesters of the Steppingstones Study intervention group. Therefore, he was more experienced with the software than other teachers who were implementing the intervention for the first time. This probably answers why Mr.
Raven was able to use the TTS software with a wider variety of tasks than a one-page worksheet. In the previous semesters, Mr. Raven only had the students use the TTS software for answering textbook questions - a single task. His experience is also noted on the observation notes. On two occasions, Mr. Raven asked the research staff to demonstrate how to use the Study Skills Tools for the students when he had students use the TTS software for their research paper. This suggests that Mr. Raven was cognizant of the tools that were available and how some tools were more useful for a specific task even though he was not able to demonstrate to the students on his own. Furthermore, despite his already experienced use, Mr. Raven commented that he would have liked to use the software with a variety of materials. This comment is an indication that he is still learning how and when to use the TTS software intervention and perhaps he sees the versatility of the software for various tasks.

Other teachers were less experienced with the TTS software. Mr. Lime had utilized it one semester before, but the software he utilized was a network version, which had quite a lot of technical issues. For Mr. Archer, Ms. Ruby and Mr. Ota, it was their first time using the TTS software. Regardless, Mr. Archer and Ms. Ruby were able to integrate the TTS software seamlessly. This may be because Mr. Archer was an English teacher and Ms. Ruby was a Special Education teacher and therefore, they were more familiar with teaching reading than other content area teachers. Additionally, since they were co-teaching, the teachers probably had more flexibility to group students and also the TTS software intervention aligned well with their inclusion goal to meet the needs of the struggling readers in their class.

**Research Question 2 – Student Level**

Cross case examination at the class/teacher level showed the overall patterns of the TTS software use were clearly influenced by the teachers’ delivery, task choices and their experience
in using the TTS software. However, the teacher/class level analysis did not shed light on the differences in reading gains. On the other hand, analysis of the students’ attitudes and perceptions towards the TTS software intervention revealed possible influences on the use of the TTS software and reading gains.

**It Reads to You**

One of the defining features of any TTS software is the speech synthesis. The results showed that more than half of the participants, regardless of the reading gains, answered what they liked about the TTS software as “reading” to them. This breakdown of students liking the reading feature of the TTS is similar to previous studies (Edmonds et al., 1996; Miller & Zahner, 2004). In close examination of how the students used the TTS software, those students who liked having the TTS software read to them used the Reading Tools continuously during the intervention period. On the other hand, those students who did not state that reading feature was what they liked, they did not utilize the Reading Tools as much after the initial introduction of the software or the first couple weeks of use. However, the fact that students liked the reading feature did not seem to have influenced the overall reading outcomes. This finding was similar to the study by Elkind et al. (1996) that reported that some individuals found using the TTS software made the reading easier and liked using the software but made little gain in reading rate and comprehension.

Interestingly, none of Mr. Ota’s ELL students, Jesse, John, and Tom, commented about liking the reading feature. This was surprising given that literature on TTS software use by ELL students found the reading feature to be seen as one of the most positive aspect of the TTS software (Chiang & Liu, 2011). Again, this may simply go back to the fact that the task was not appropriate for using the Reading Tools. Mr. Ota’s one page worksheet, perhaps, was structured
in a way that the reading feature was not something that worked well. There is a need to examine the teachers’ materials more closely to know how the TTS software worked especially if the teachers did not use a book or a textbook containing longer texts.

**Purposeful Usage**

The differences in reading gains and the subtle differences in the TTS software use could be the result of whether students perceived the TTS software as helpful to use for a particular purpose. As found from analyzing the students’ comments, students in the HG and MG were able to utilize specific tools that provided support for their task on hand, whereas students in the NG group were unsure of how to benefit from the various tools for the task on hand. This difference was exemplified in Mr. Ota’s students. All of them did not comment about liking the reading feature; however, Jesse (HG) and John (MG), found the TTS software to be helpful. Jesse used the tools to find key points and John used to look up definitions. They used the dictionary tools throughout the intervention period. On the contrary, Tom (NG) commented on how the software was not helpful and his comment also focused only on the reading feature. His use of the TTS software also showed that he might have been unsure of how to use the tools in completing the one page worksheet. In comparison to Jesse and John, Tom was logged on longer and was using the reading feature longer even though the one page worksheet probably did not have a lot of text to listen/read. The longer duration on the TTS software without much result could also imply that Tom was disengaged.

All students who participated in the study were struggling readers; however, perhaps HG and MG students in comparison to the NG students may have been at a different stages of reading development and were better at strategic processing to monitor their reading while completing assignments (Alexander, 2005). This finding is aligned with Proctor et al.’s (2007)
study on the tools use in an online learning environment. They found that participants who meaningfully used the available tools (e.g., the strategy coach, glossary use) made greater gains in the post-comprehension reading test. In other words, the HG and MG students were those who were able to know how to use the TTS software that helped them for a specific reading task. Similarly, Marino (2009) reported that low ability readers did not utilize the technology-based tools as frequently as proficient readers. The students in the NG group may not have known how or when best to utilize the TTS tools within the short intervention period.

**Ability to Understand from Listening**

Good auditory comprehension was one of the predictors of improved comprehension using the TTS software in the studies conducted by Elkind, et al. (1996) and Elkind (1998). Although the current case study did not assess students’ listening comprehension, the students’ comments about the TTS software suggest variability in their ability to understand from listening. This in turn may have contributed to the patterns of the TTS software use and different reading gains. Seven out of the eight students in the MG and NG commented that they did not like the voice of the TTS software or they had a hard time understanding. This is in contrast to zero students in the HG commenting about the voice or having difficulty understanding the computer reader. This finding clearly showed the group difference between the HG students and the MG/NG students.

Students who just expressed disliking the voices may be able to become used to the voice over time since most of them said they still liked the reading features of the TTS software. The current speech synthesis has improved significantly from the past, and the voices available are much more naturally sounding. Therefore, prior to using the software, it may be important
for the students to familiarize themselves with these voices and perhaps use easy narrative texts to practice listening to the voice.

For students who expressed difficulty understanding, however, more careful attention is needed. John’s (MG) difficulty understanding may have been due to a language (ELL) barrier whereas Vilma (NG) and Hank’s (NG) difficulties may have been due to weak auditory processing. In Tom’s case, he said the TTS software was irritating and that he would rather read the book on his own. In looking at his silent reading rate, his pre-intervention rate was at 256 wpm, which is the speed at which typical high school or college students read. Therefore, with the TTS software, Tom probably had to slow down his reading rate significantly and his reading strategy did not match the way the software was reading. In cases where students struggle with auditory comprehension, the Reading Tools may not be the most appropriate tools for these students to use to improve their reading. However, they may still be able to utilize other tools (i.e., Study Skills Tools or Dictionary Tools).

The finding that MG and NG students disliked or had difficulty understanding the TTS voice is also significant because it gives a glimpse of what may have been happening while the students were using the TTS software. Though not captured in the overall radar chart pattern of TTS software use, the individual TTS log shows a few students’ over utilization of certain tools, especially in adjusting the speed or the voice. It was noted that Hank (NG) and Nobu (NG) continued to adjust the voices occasionally throughout the intervention period. The TTS log also showed that they tried to read silently without the speech synthesis but have the TTS software highlight the words as the software “read silently” along with the students. This could have been a sign that they were having trouble listening and understanding. A careful analysis at the micro level of TTS software use may be needed to further examine whether there are differences in the
usage for those students who have difficulty listening in comparison to those who do not have listening difficulty.

**Post Intervention Attitudes**

The results of the overall attitudes from the pre-post survey responses showed that there were group differences in the post attitudes towards the use of the TTS software intervention as well as differences at the teacher/class level. It is no surprise that the NG students were less positive in comparison to the MG or the HG group students. Their lack of desire to use the TTS software again aligns with how they were unable to use the TTS software in a purposeful manner and how some of them had difficulty understanding. The only NG student who had a positive attitudes post-intervention was Hank. This is likely a reflection of how Mr. Archer and Ms. Ruby seamlessly integrated the TTS software in their class and how they provided task choices that were appropriate in utilizing the TTS software. In fact, all three students from Mr. Archer and Ms. Ruby’s classes stated they would definitely want to use the software again, felt that the software was user friendly and helped them understand better. Thus, this again supports the idea that the classroom teacher influences their students’ use of the TTS software.

As the results showed, HG students had mixed results. The two students, Mia and Terry, in the HG who had more positive attitudes were students with disabilities. It is likely that for these two students, the use of the TTS software was both compensatory and remedial. Mia’s use of the TTS software exemplified her needs. As the week progressed, she used different tools and her comment about what she least liked about the TTS software was that she was allowed to only use it once a week. Mia and Terry are enabled users (Parr, 2012) who recognize the benefits of the TTS software and appreciate the support that it provides. The other two HG students had neutral attitudes. Perhaps for these two HG struggling readers, the TTS software use might not
have been a necessity in their classes that they used the software for, though helpful. Thus, these students can be classified as a “contextual chooser” (Parr, 2012), in which the TTS software use is “a scaffold, a motivator, and a regulator that maintains focus, enhances concentration, and supports engagement” (p.310). As such, they may find the TTS software more useful in another class, context or even interest (Alexander 2005).

Probably the most unexpected finding about the overall attitudes is the MG students’ attitudes. As a group, they responded more positively about the TTS software intervention than the NG and the HG students. This group of students, regardless of disability or ELL status, responded that they would want to use the TTS software again. These MG students could also be classified as Parr (2012)’s enabled users. The MG students found purposeful use of TTS software and the majority of them liked the TTS software reading to them. Therefore, having the TTS software support available and becoming more familiar with the TTS software use can enable them to become more efficient and effective in strategic processing as they become competent readers (Alexander, 2005).

**Perceptions About TTS**

The students’ pre and post intervention perceptions of the impact of TTS software use on vocabulary and comprehension did not impact their TTS software use nor did it contribute to the differences in reading comprehension gains. Further questions about why students think that the TTS software would improve vocabulary or comprehension would be necessary to better understand the influence of their perceptions on the use of the TTS software.
How Should TTS Software be Used?

If students are to acquire these advanced reading skills and become critical readers within their disciplines, then teachers need to go beyond assigning merely what to read by giving students explicit explanations about the why and how of their reading (Jacobs, 2008, p.14)

The results of the current study made clear that the teacher’s delivery, task choices and previous experience with the TTS software influenced students’ patterns of the TTS software use regardless of students’ reading gain groups. Some might argue that this may not be a surprising finding. Nonetheless, this is an important finding as the teacher’s implementation of the TTS software intervention, an intervention that was already found to be effective, could further enable or even delay adolescent struggling readers from developing their reading skills using the TTS software. The question remains whether there is a particular implementation practice that augments the reading outcomes (i.e., vocabulary and comprehension) for all struggling readers including students with disabilities and ELL students. The simple answer at this time is that there is no one pattern of the TTS software use to improve reading outcomes. However, in considering the results of the teacher delivery, task choices, students’ attitudes and perceptions of the TTS software use from the current case study, below are some recommendations for teachers to consider in implementing the TTS software intervention with a range of struggling readers in secondary grade classrooms:

1. Give ample time to become familiar with the TTS software and its tools before implementing the intervention.

2. Demonstrate the TTS software and its tools use together as whole class instruction and gradually release the responsibility to students for independent use.
3. Once familiar with the software, consider using the TTS software for different assignments and tasks.
   a. Think about the goals and objectives of the assignments and tasks to assess the type of TTS tools that should be used or that would be helpful.
   b. Model purposeful tools use for specific tasks to foster strategic processing.
   c. Do not overwhelm yourself or the students by utilizing too many tools at one time.

4. Use the TTS software for longer passages rather than a short worksheet when possible to allow for sustained reading.

5. Articulate to students how TTS software could help in improving reading vocabulary and comprehension.

6. Be cognizant of students’ reading developmental stages and their strengths and needs in reading.
   a. Have students self-evaluate their reading skills.
   b. Jot down possible challenges in reading observed (e.g. difficulty understanding from listening).
   c. Remember that some students may need TTS software as an AT and therefore, need to use the TTS software for both short and long assignments.

7. Have students explore TTS software with materials of interest to them to help familiarize them with the software and its tools.

8. Provide students with options to use the TTS software in various classes as well as outside of school.
9. Monitor students’ TTS software and tools usage to know whether students are using the TTS software tools appropriately for a given task/assignment, and provide feedback on their use.

In addition to these recommendations, although it was not the main focus of this study to evaluate the teacher implementation, it seems imperative that there is an ongoing training for the teachers on the use of the TTS software. This will enable the teachers to understand why TTS software use is important and effective, be knowledgeable of adolescent reading development and theories, and be equipped with various ways to use the intervention within their curriculum (Diamond, 2006). Miller & Zahner (2004) found in utilizing Kurzweil that most teachers were unable to make judgments about how much time is needed to use the program, and also how to structure their instruction in utilizing the software.

Additionally, teachers need to become more aware that their adolescent struggling readers are a diverse group of students and there is a need to shift our thinking by not classifying all of the students as one group of “struggling readers” (Alvarez et al., 2009). Clearly, from the study, some struggling readers benefited more from using the TTS software. Therefore, the students’ stages in their reading development should be considered in how to best implement interventions, such as the TTS software. There is no question that the TTS software is an easily accessible, useful tool that should be more widely available to all students in alignment with the UDL principles. The TTS software can provide access to grade level text and at the same time can enable the students to become a better reader. Yet, results from this study was a reminder that just providing the tool may not provide the scaffolding needed for these students to become a competent user and thus, a competent reader (Marino, 2009; Proctor et al., 2007). Just as it takes time for the teachers to become comfortable and familiar with the TTS software, the
students will also need time to develop these skills and become independent users of the TTS software tool. Such independence is necessary for adolescent learners as they move through high school and transition into adulthood. Parr (2012) stated that when the students are able to make their own decisions about the use of TTS, the TTS software could provide support in the “development of metacognitive strategies, student dialogue and collaboration, spontaneous reader response, and most importantly self-efficacy and self-advocacy” (Parr, 2012, p.1423).

Limitations of the Study

To capture the TTS software pattern as a whole, the radar chart analysis was used. With the use of the radar chart technique, the patterns of the TTS software use became apparent at the teacher/class level. However, because of the limited use of some of the TTS tools by the students, the chart was not as sensitive in illustrating small differences from one case to another. For instance, Study Skills Tools were used by the students in Mr. Raven’s and Mr. Lime’s classes; however, this use was not visually represented on the radar chart due to the larger scale of the Average Total Minutes and Average Reading Minutes indices. Consideration was made to adjust the scales for each variable, but that would not have captured the overall proportion of use of the TTS tools in relation to the amount of time students spent on the software. Therefore, subtle individual differences were not well captured and perhaps a bar graph for Study Skills Tools and Dictionary Tools may have been helpful in visualizing the specific tools use. Also, in using the average duration and frequency, the data did not capture the students’ day-to-day usage pattern for a specific task. Thus, the averaging may have masked the actual pattern of the TTS software use. Additionally, the patterns of use for some students may not have been as frequent or may have been more frequent because the TTS software was used in pairs or as a small group. This is because some of the classes did not have enough computers for a 1:1 implementation or
some computers had Internet connectivity issues. Similarly, students usage may be inaccurate because students forgot to log-out, or once they logged on, they had the TTS running but started doing another activity. Like Parr’s (2012) cases, students may have had the software running, but at the same time they may have been talking with their peers or they could have been doing other tasks. Also, there are other tools within the software that the students utilized that were not recorded and logged. Such tools may have been what assisted the students rather than the tools recorded for the study. Finally, the major drawback of this study was that no additional data were collected through student interviews or teacher interviews to verify the TTS usage log and to also evaluate the students’ stages of reading development.

**Future Directions**

This study was one of the first studies to investigate the students’ patterns of the TTS software use by adolescent struggling readers. The study investigated an overall pattern of the TTS software use, but more studies investigating when and how struggling readers used specific TTS software tools are needed to understand why the TTS software intervention was effective. For instance, did the students change the rate of the speech when coming to a difficult text? At what rate did the students read the passage? Did the students know when to use the specific Study Skills Tool? Such research can provide better guidance for teachers and students to be able to use the TTS software as an effective intervention and educational scaffolding tool to meet the diverse needs of the struggling adolescent readers.

Some additional research questions to consider:

Are there specific patterns of TTS software use suitable for specific subjects? Specific tasks?
Are there specific patterns of TTS software use suitable for each stage of reading development?

Does TTS software use enhance surface-level reading strategies? Deep-processing reading strategies?

What are the impacts of TTS software use on listening comprehension? Will the software improve listening comprehension?

What are the impacts of TTS software use on self-efficacy in reading? Do students who have higher self-efficacy in reading make greater gains using the TTS software than those students with lower self-efficacy in reading?

**Conclusion**

The current research investigated how the Steppingstones Study participants who made HG, MG, and NG in reading comprehension used the TTS software. Twelve cases were examined to investigate the patterns of the TTS software use. Contrary to the initial assumption that the patterns of TTS software use would differ by reading gains, the converging evidence from multiple sources of quantitative and qualitative data utilized in the study suggests that the patterns of the TTS software use were greatly influenced by the teacher delivery, task choices and experience in using the TTS software. Additionally, student level analyses revealed that more NG and MG students reported difficulty understanding the text from the TTS software use compared to HG students who expressed no difficulty. Further, HG and MG students were able to use the TTS software with more purpose in comparison to the NG students. HG and MG students utilized the TTS software tools that enabled them to complete the tasks faster and understand better. Therefore, those students who were able to figure out what tools were useful in completing certain tasks were those students who were able to benefit from the TTS software.
and make gains in vocabulary and comprehension. Such differences amongst the HG/MG versus NG students may be reflective of where they are in their stages of reading development although all students were struggling readers reading at least two grade levels below their actual grade. HG and MG students may have been in the early to mid competence stage where as NG students may have been still at the acclimation stage of reading development.

Regardless of HG, MG, or NG, the teachers’ influence was prevalent with the TTS software use. Having teachers closely reflect on how they deliver and model the use of the TTS software as well as on their choices of tasks to assign may foster seamless integration of the TTS software within their classes. This in turn would lead the struggling adolescent readers to more comfortably use the software, have positive attitudes towards the use, and benefit from the TTS software use. Such integration of TTS software will also align with the UDL principles by providing choice, flexibility, option and engagement (Rose & Meyer, 2000) and promote access to grade level materials in an authentic environment. Ultimately, the TTS software should be available to all students when needed, as it has been found to be effective in improving the reading outcomes of all struggling readers, regardless of disability status or ELL status.
This Reference is written for teacher/administrators, and provides information about the Kurzweil 3000 for Windows Version 12 user interface, common tasks, and important options in condensed format. Some functions, features, and procedures presented, such as scanning, apply only to the Kurzweil 3000 Professional product.
About the Text-to-Speech Project and this Manual:

Text-to-Speech Phase 2, funded by Steppingstones of Technology Innovation for Children with Disabilities, is a project in which researchers from the Center on Disability Studies (CDS) at the University of Hawai‘i, Manoa, will team with teachers across twelve public high schools on O‘ahu to assess the effectiveness of the text-to-speech software, Kurzweil 3000™. Use of the software as an intervention tool will be integrated with reading tasks in teachers’ existing curricula. Various reading skills will be measured at the beginning and end of a one-semester period and the project will be funded for a total of three years. In the previous phase one stage of the study, participating students were found to have increased their overall reading level by around two grade levels.

This training manual, written for educators and students, provides information about using basic features of Kurzweil 3000™ Version 12 for Windows in condensed format. The manual is to be used in conjunction with the Text-to-Speech Phase 2 Project of the Center on Disability Studies, University of Hawaii at Manoa. Some functions, features, and procedures presented, such as scanning, apply only to the Kurzweil 3000™ Professional product.

About Kurzweil 3000™

Kurzweil 3000™ software offers integrated features that promote and aid students in reading, studying, and writing. Based on Universal Design for Learning principles, it provides users with multiple ways to access information and curriculum. It also provides tools to help one accomplish tasks independently, practice active learning skills, and demonstrate acquired knowledge.

For teachers, Kurzweil 3000™ offers easy-to-use features that enable them to accommodate a wide range of student learning styles, to quickly respond to intervention requirements, and to follow standardized test taking guidelines.

*This manual is adapted from “Foundations Workshop” Participant Workbook for Kurzweil 3000™ for Windows Version 8 (2004 2nd Ed.).
Acknowledgements:

This material is based upon work supported by the Steppingstones of Technology Innovation for Children with Disabilities under Grant No. CFDA 83.327A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Acknowledgements:
Overview of T2S Project Software Manual

The T2S Project Software Manual is designed to help educators and students use the text-to-speech software Kurzweil 3000™ (Windows Version 12). The manual may be used to guide individual or group instruction.

Section 5 is optional and has been included for those wishing to use the software for writing and editing.

Getting Started
This section walks the user through the basic operations of T2S software such as opening & closing the software, using menus, accessing help, and opening & viewing documents.

1. Reading
This section guides users in customizing their reading experience in Kurzweil 3000™. Users can learn how to start & stop reading, adjust the reading speed, and change the reading voice.

2. Study Skills
This section instructs users on using note-taking tools such as highlighter, circle tools, footnotes, sticky notes and bookmarks.

3. Dictionary
This section explains how to utilize built-in reference tools to look up word meanings and synonyms, and access online encyclopedias.

4. Scanning
This section helps users scan reading materials to be used in the Kurzweil 3000™ software.

5. Web Reading
This section gives instructions on how to have text on web pages read aloud to you. Note: The use of this feature requires Mozilla Firefox Web Browser and a downloadable add-on.

X. Writing & Editing
This section explains how to use Kurzweil 3000™ to write and edit text.
In this section, basic operations of the T2S software will be covered, including opening & closing the software, using menus, accessing help, and opening & viewing documents.

### 0.1 Starting & Stopping Kurzweil 3000™

**To start Kurzweil 3000™:**
Double-click the Kurzweil 3000 icon on the desktop.

**To stop Kurzweil 3000™:**
Do one of the following:
- From the File menu, choose Exit.
- Or click Close.
- Or press ALT+F+X.

### 0.2 Menus

For mouse users, menus in Kurzweil 3000™ are located along the top of the application window. In many instances, Right Mouse Button menus are available by pressing the Right Mouse Button.

Keyboard users can use the following procedure for quick access to menu items, and where available, Kurzweil 3000™ offers keyboard shortcuts for performing actions.
0.3 Help

To access online Help, do one of the following:
- Click the Help icon on the Main Toolbar.
- Press the F1 key.
- In dialog boxes, click the Help button.

To search Help pages, do one of the following:
- Type a topic into the Search text box & click Search.
- Click Index and type the first letter of your desired topic.

To view How To video clips:
- Go to the Help menu and select How To, then double-click the desired topic from the menu.

0.4 Opening and Viewing a Document

To import a non-electronic source into Kurzweil 3000™:
- Use the Scan button or Scan menu

To import a electronic source (pdf, html or cd-rom):
- Use KESI virtual printer option.
- Select KESI virtual printer option in the originating application.

To import a .txt or .rtf file, do one of the following:
- Click the Open button
- Click on File menu, then click Open.

The following file formats are supported:
- Kurzweil 3000 and Kurzweil 1000 (.KES) text and image
- Text File (.TXT)
- Rich Text Format (.RTF)
- Microsoft Word files (.DOC)
- Microsoft Office 2007 (.DOCX)
- Image Files (.TIF, .BMP, .JPG)
- Portable Document Format (.PDF)
- DAISY (.OPF)
Reading Tools are a set of tools that help you customize your reading experience in Kurzweil 3000™. You can use the reading tools to start & stop the reading, and change reading speed, and voice.

1.1 To have a text read:

- Click Open button
- Select the text you want to read
- Set cursor at desired starting point
- Click Read button on main toolbar

1.2 To pause the reading:

- Click the Pause button on main toolbar (same as read button)

1.3 To toggle audio & silent reading:

- Click the Audio/Silent toggle button on the main toolbar

1.4 To repeat the reading of a text or move forward in the text:

- Click the arrow buttons on the main toolbar
1.5 To change reading voice:

- Go to the Tools on the menu bar
- Go to Options > Reading > Speaker
- Choose the speaker of your preference

1.6 To change the reading speed, do one of the following:

- Click the arrow buttons between at and WPM on the main toolbar.
- Type in the preferred speed in the box next to WPM.

1.7 To turn pages:

- Click on the up/down arrows next to the page number on the reading toolbar.

1.8 To change text & highlight color:

- Go to Tools, then Options.
- Go to the Image tab.
- Click the preferred text & highlight color
Study Skills Tools is a set of tools that can be used while you are reading. It includes tools such as highlighters, circle tools, footnotes, sticky notes and bookmark.

### 2.1 To show the Study Skills Toolbar:

- Show the **Study Skills Toolbar** by right clicking the empty space by the tools
- Select the **Study Skills Tools** option
- Click the Green Toggle along the left edge of the Toolbar.

### 2.2 To use the Color Highlighter Pens & Circle Tools:

- Choose a color that you want to use
- Drag over the desired text using the mouse or use a Circle Tool to circle the selection.
HIGHLIGHTING TOOLS

2.3 To highlight or circle text

- Select the text to highlight or circle, then click the desired color Highlighter pen or Circle tool in the Study Skills Toolbar.
- Or click the color Highlighter or Circle tool first then select the text.

Example of highlighted text

2.4 To erase highlights or circles

- Select the text that has color highlighting or circling, then click the Eraser in the Study Skill Toolbar.
- Or click the Eraser first then select the highlighted or circled text.
2.5 To find highlighted or circled text

- Open the Edit menu, select Object from the Find submenu.
- In the Find Object dialog, select Highlight.
- Click Find.

2.6 To Create a Sticky or Text Note

- Click the Sticky Note or Text Note button in the Study Skills Toolbar.
- Click in the text where you want to place the note.
- Type desired text into the note.
- Click outside the note when you are finished.

Note: Sticky Notes is available only in image documents when you cannot directly type into the text you are viewing. Footnotes is available for all types of documents.

2.7 To Create a Footnote

- Click in the document where you want to place the Footnote marker.
- Click the Footnote button in the Study Skills Toolbar.
- In an image document, a number marker appears in the note location and the Footnote window opens.
- In a text document, the text closest to the note changes to blue underlined text and a number appears next to the note.
- Type in the Footnote window.
- When you are finished, click the Close Footnote button in the Study Skills Toolbar.
2.8 To Open the Bookmark Dialog

- Click the Bookmark button in the Study Skills Toolbar.

2.9 To Add a Bookmark

- Click in the document where you want to place the bookmark.
- Open the Bookmark dialog.
- Type the description, then click Add.

2.10 To Sort Bookmarks

- Open the Bookmark dialog
- Click to sort by Alphabetic or Reading order.
2.11 To Go to a Bookmark

- Open the Bookmark dialog
- Click on the description of the Bookmark that you want to go to, then click Go To.

2.12 To Delete a Bookmark

- Open the Bookmark dialog
- Click on the desired Bookmark, then click Delete.

2.13 To Search for Bookmarks

- From the Edit menu, select Object from the Find submenu.
- In the Find Object dialog, select Bookmark, then click Find.
For easy reviewing, you can pull out all or part of your notes, including footnotes, bookmarks and information you highlighted, circled, or typed in Sticky Notes and place them in a new document.

2.14 To Extract Highlighted Notes, Footnotes, Sticky Notes, & Bookmarks (all your notes for reviewing)

- With the document containing the highlights and/or notes you want to extract open, go to the File menu,
- Choose Extract.
- From the Extract submenu, select Notes and Highlights.
- In the dialog, select the notes and/or highlights you want to extract.
- For Notes, specify the Note types you want: Footnotes or Sticky Notes.
- For Bookmarks, select Bookmarks.
- For Highlights, select Highlights.
- Click OK.
Dictionary Tools allows you to find the definitions of words you do not know while you are reading. You can look up unknown words in the built-in dictionary and access online encyclopedias and other reference sites.

3.1 To Look up a Word in Document

- Select a word in a document
- Click the desired reference tool button on the Main Toolbar.

3.2 To Look up a Word You Type

- From the Reference menu, choose Look Up Word I Type.
- Type the word, then click the desired reference tool button on the Main Toolbar.
- Or use the Reference menu.

3.3 To Look up Information in Online Encyclopedias/Reference Sites

- You must have an Internet connection to look up information from online reference sites.
- Select a word or phrase.
- From the Online menu, select Online Reference Lookup.
- In the Online Reference Lookup dialog, select a Search Site from the list, then click Search.
Scanning Tools allow you to scan your reading materials into the Kurzweil 3000™ software. After they are scanned, you can access them from the software.

### 4.1 To Do Basic Scanning

- Make sure your scanner is turned on.
- Place the material to be scanned on the document table.
- Click the **Scan** button in the **Main Toolbar**
- Progress messages appear as Kurzweil 3000™ captures the image and “recognizes” the text.
- When the scan is complete the page image appears in the Kurzweil 3000™ document area.
- Each new page you scan is added to the end of the document.
- To cancel scanning, click the **Cancel Scan** button.

### 4.2 To Do High-Speed Scanning

- If you are using a high-speed scanner, it is often more efficient to use that scanner’s software than to use Kurzweil 3000™. You can use the Kurzweil 3000™ Automater to convert the scanned TIFF files into KES or PDF file format.
- See online Help for details on using the Automater.
### 4.3 To Open Scanning Options Pane:

- From the **Tools** menu, select **Options**, then click the **Scanning** icon.

### 4.4 To Display the Document Preparation Toolbar Set:

- When preparing documents, it may be helpful to display the Document Preparation toolbar, giving you quick access to the tools you will be using most often.
  
- Open the **Tools** menu, from the **Customize** submenu.
- Choose **Apply Toolbar Set**, then select **Document Preparation**.
Web Reading Tools enable you to have text in websites read aloud. Note: This feature requires Mozilla Firefox Web Browser & the appropriate add-on.

### 5.1 To Launch the Reading the Web Toolbar

- Go to the **Read** menu.
- Click **Read the Web**.
- You should have a **Read the Web** toolbar at the bottom of the screen.

### 5.2 To Start Reading the Web

Just like the normal T2S software, you are able to control your reading experience. Use the **Read the Web** toolbar to:

- Have text read
- Adjust reading speed
- Adjust reading modes
- Go forward & backward
- Access dictionary tools
- Magnify words
- Extract text

You can operate the **Reading the Web** Controls just as you did in the T2S software.
The T2S software also has numerous tools to help you write and edit. Opening the Writing Toolbar, gives you access to the frequently used writing & editing tools.

**x.1 To Start Writing**
- Click on the Write Menu

**x.2 To Create a New Text Document**
- Do one of the following:
  - In the Main toolbar, click on the New button.
  - From the Write menu, select New- Draft- Blank.
  - From the File menu, select New– Draft– Blank.
  - Begin writing.

**x.3 To Use a Template to Start Writing**
From the Write menu, select:
- New- Brainstorm– from Template
- New- Outline– from Template
- New- Draft– from Template
- Begin writing by replacing the instruction with your own text.
x.4 To Start New Brainstorm Diagram

- From the Write menu or the File menu, select New-Brainstorm-Blank.
- Begin writing from a Brainstorm diagram by selecting one from the Brainstorm Palettes displayed on the right side of your writing screen.

x.5 To Start a New Outline Document

- From the Write menu or the File menu, select New-Outline-Blank.
- Begin writing from an Outline document by selecting one from the ‘Outline Palette’ displayed on the right side of your writing screen.

x.6 To see the underlying text:

- Click Edit
- Click Correct Recognition menu
- Click Underlying Text.
x.7 About Using Spell Check

The T2S software lets you check spelling in image documents to correct scanning errors, as well as in text documents to correct composition errors. Note: Making spelling corrections in image documents changes the underlying text that Kurzweil 3000™ reads; it does not change the image text on the screen.

x.8 To Spell Check a Document

- In a document, click the Spell Menu.
- If the software thinks a word is misspelled, it opens the Spelling Correction dialog.
Bibliography

Assistive technology for the nation’s most challenged students. (n.d.) Retrieved from www.kurzweiledu.com


I CAN DO THE FOLLOWING: For each of the 5 TOOLS, mark X on the items you know how to do.

1. READING TOOLS
   - Start reading
   - Stop/Pause reading
   - Change reading speed (faster or slower)
   - Change voice
   - Change pages (previous or next page)
   - Zoom in or out of a page

2. DICTIONARY TOOLS
   - Look up the definition using the dictionary
   - Look up a syllable for pronunciation
   - Look up a synonym/antonym

3. WEB/INTERNET TOOLS
   - Access the Internet from the reading program

4. STUDY SKILLS TOOLS
   - Use the highlighter and circle pens
   - Erase highlights and circle marks
   - Create sticky notes
   - Move sticky notes around
   - Delete sticky notes
   - Extract highlights & sticky notes on to a new window/document
   - Create bookmarks
   - Create a new text file

5. SCANNING TOOLS
   (FOR TEACHERS ONLY)
   - Scan reading materials using the reading program

SCORE (for project staff use)

Reading Tools (4) _______ Dictionary Tools (3) _______ Scanning Tools (1) _______
Study Skills Tools (8) _______ Internet Tools (2) _______
Student Score _______ / 17 possible        Teacher Score _______ / 18 possible

95% proficiency = 16 for students and 17 for teachers
A Review of Text-to-Speech Software Use

for Improving the Reading Comprehension of Struggling Adolescent Readers

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Abstract

This systematic review of literature examined the empirical research on the effects of the text-to-speech (TTS) software on reading comprehension of students who are struggling readers in secondary school since the reauthorization of IDEA 2004. Studies chosen for this review included studies published between 2004-2011 and used the TTS software as an intervention to improve reading comprehension. Seven studies met the inclusion criteria. The results of the review revealed that all but one study used the TTS software with highlighting feature; the majority of the studies described the TTS software as a compensatory tool to access curriculum and grade level materials; all but one study measured improvement in reading comprehension while using the TTS software; and all but one study reported gains in reading comprehension while using the TTS software or after using the TTS software for a certain duration of time. Future studies should include the specific components of the TTS software used and test the effectiveness of the TTS software with and without the use of the software to determine its effect as a compensatory tool and/or a remediation tool for secondary students who are struggling readers.
A Review of Text-to-Speech Software Use for Improving Reading Comprehension of Struggling Adolescent Readers

Many students enter secondary school with poor reading skills and are often unable to catch up with their peers, especially with the high demand on independent reading skills required for variety of texts and materials used in secondary schools (Disseldorp & Chambers, 2002). Sadly, such demand in reading is one of the leading reasons for high school students to dropout of the schools in the United States (Alliance for Excellent Education, 2007; Kamil, 2003; Snow & Biancarosa, 2003). In fact, about 7,000 high school students with low literacy skills drop out of school every day in the U.S. (Alliance for Excellent Education, 2007). Even if the students do not drop out, limited reading skills are a barrier to transition into postsecondary education and into today’s competitive job market (Alliance for Excellent Education, 2011; Slavin, Cheung, Groff, & Lake, 2008). With accountability programs in place, more high schools are providing reading instructions (Slavin, Cheung, Groff, & Lake, 2008). Still, the recent outcomes in reading proficiency of secondary school students have not changed drastically over the past 3 decades (National Center for Education Statistics, 2011). Only about 30 percent of high school students read proficiently (Alliance for Excellent Education, 2007), and only 34 percent of 8th graders read at or above proficient level (National Center for Education Statistics, 2011). The reading gap between those reading at or above proficiency and those reading below is almost too wide to address by the time struggling readers are in high school (Edyburn, 2007), and it affects students’ learning and motivation (Graham, Pegg, & Alder, 2007).

Evidence Based Reading Instruction

Despite the challenges faced in the secondary schools in reading, with the introduction of
Response to Intervention (RTI) with the reauthorization of the Individuals with Disabilities Education Improvement Act (IDEA, 2004), there has been some progress in providing reading interventions to students in middle and high schools (Slavin et al., 2008; Vaughn et al., 2008). The RTI process typically has multi-tiered construction where academically and behaviorally struggling students are provided with a series of evidence based interventions with progressing intensity (e.g., Fletcher et al., 2004; Hollenbeck, 2007). Thus, several studies on evidence-based practices in reading have been conducted to investigate the target skills and the types of interventions that are most effective for struggling readers in secondary school (Biancarosa & Snow, 2004; Edmonds et al., 2009; Graham et al., 2007; Scammacca, Roberts, Vaughn, Edmonds, Wexler, Reutebuch, & Torgesen, 2007; Slavin et al., 2008). One such intervention involves the use of technology as a tool. More specifically, assistive technology (AT) such as text-to-speech (TTS) can be used for teaching students with reading and learning disabilities to provide multisensory engagements with the class material (Elkind & Elkind, 2007; Edyburn 2004, 2003 & 2000; Silver-Pacuilla, Ruedel & Mistrett, 2004).

**Text-to-Speech Software**

TTS software is one example of AT that has become a common tool for struggling readers in secondary schools and colleges, and has been widely accepted as a form of accommodation for students with disabilities (Engstrom, 2005; Silver-Pacuilla & Fleischman, 2006; Silver-Pacuilla et al., 2004). TTS software, sometimes referred to as ‘screen reader,’ ‘text reader’ (Disseldorp & Chambers, 2002) ‘scan-and-read’ (Edyburn, 2007), or ‘supported e-text’ (Anderson-Inman & Horney, 2007), is a speech synthesizer that provides visual and auditory input of any text on the computer screen (e.g., Balajthy, 2005; Elkind & Elkind, 2007; Roberts, Takahashi, Park, & Stodden, 2012). Thus, the software is able to assist struggling readers to read
materials they are unable to read independently. Often, the TTS software can highlight the text as it reads and adjust the speed and voice of the reader (Manset-Williamson, Dunn, Hinshaw & Nelson, 2008; Roberts et al., 2012).

**Reading Comprehension and TTS Software**

Reading comprehension is the ultimate goal of reading (Faggella-Luby & Deshler, 2008; Sweet & Snow, 2003). However, many students who struggle in reading in secondary school have difficulty with comprehension due to insufficient basic skills (e.g. phonological awareness, decoding), fluent reading, inadequate vocabulary, inability to apply reading strategies, and/or deep processing of text (Roberts, Torgesen, Boardman, & Scammacca, 2008). As found by Scammaca et al.’s (2007) meta-analysis of interventions for adolescent struggling readers, older students with reading difficulties benefit from word level and text level interventions. TTS software is able to provide such help with decoding of the words and reading fluency (Manset-Williamson et al., 2008), which allows for more energy for comprehension of the text (Forgrave, 2002; Lundberg, 1995). Several early studies have focused on improving the reading comprehension outcomes of struggling readers using TTS software (e.g., Leong, 1995; Elkind, Cohen & Murray, 1993; Farmer, Klein & Bryson, 1992, Raskind & Higgins, 1999). As synthesized by Elkind and Elkind (2007), such studies have mixed results and not all students benefited from the TTS software use. Moreover, only a few studies focused on secondary school students. Similar synthesis has been conducted for the effectiveness of AT in general (Roberts & Stodden, 2004) or of computer assisted instruction that include TTS, but not specifically of TTS software.

Technology integration within the classroom has much improved since the 90’s and more evidence based practices are needed with the introduction of RTI. In addition, there are many
free and commercially available TTS software available (see Berkely & Lindstron, 2011) that there is a need to further research on the type and extent of such TTS software use and identify whether a specific type of TTS software or all types of TTS can be an effective tool for struggling secondary school students (Moorman, Boon, Keller-Bell, Stagliano, & Jeffs, 2010).

The purpose of this synthesis was to examine recent empirical studies on the effectiveness of TTS software, in improving reading comprehension of middle school and high school students who are struggling readers. This review addressed the following research questions:

This review addressed the following research questions:

1. What types of TTS software and associated tools were used for intervention to improve reading of struggling readers in secondary school?
2. How was the TTS software implemented to improve reading of struggling readers in secondary school?
3. How were reading comprehension outcomes measured (e.g. instruments, with or without the use of TTS)?
4. What were the reading comprehension outcomes of struggling readers in secondary school who used the TTS software?

Method

The method for this review was a systematic study selection procedure using seven inclusion criteria and three exclusion criteria.

Inclusion Criteria

Criteria for inclusion of intervention studies in this review were as follows:
1. Studies used an experimental, quasi-experimental, mixed-methods, or single-subject case design;

2. Studies had to have involved middle and/or high school students in grades six to 12. Studies involving middle schools that began at grade five was also included.

3. Studies had to have their subjects identified as struggling readers, having learning disabilities (LD), or reading disabilities. A struggling reader was defined as individuals reading at least one grade level below their age/grade group peers. Baseline/pretest reading level had to be provided if disability status was not confirmed.

4. At least one of the studies’ intervention conditions had to have the use of the TTS software.

5. Studies’ dependent measures had to have included measure of reading comprehension. The measures could have been experimenter-made measures.

6. Studies must have been published in a peer reviewed journal between 2004 and 2011.

7. Studies could have taken place in any location, but the report had to be available in English.

**Exclusion Criteria**

Three exclusion criteria were specified for the initial searches to narrow down the studies.

Exclusion criteria were applied if:

1. Studies involved the use of computer programs/computer assisted instruction that have pre-packaged content/curriculum as the intervention (e.g., Fast Forward, Read 180, etc.).

2. The use of the TTS software was on a phone, reading pen, or any other handheld devices.

3. Studies participants were primarily students with visual impairment, who were blind, and/or who were deaf or hard of hearing.
Search Procedures

For this literature synthesis five databases were searched: Educational Resources Information Center (ERIC), Academic Search Premier, JSTOR Arts and Science Collection, PsycINFO, and Google Scholar. Ancestral searches were performed from studies that met the inclusion criteria using their references. Hand searches were also conducted for Journal of Special Education Technology, Journal of Research on Technology in Education, and Contemporary Issues in Technology and Teacher Education. Search terms included “computer assisted learning,” “assistive technology,” “reading intervention,” “reading comprehension,” “middle school”, “high school,” “secondary school,” “adolescent,” “reading,” “text-to-speech,” “Kurzweil,” and “struggling reader.” These terms were searched individually and in combinations. The timelines was set from 2004 to 2011. The year 2004 was selected for three reasons: First, the year marks the reauthorization of IDEA, which also marks the beginning of RTI and the emphasis on evidence based practices in general education classes. Secondly, the year also marks the reauthorization of the Improving Access to Assistive Technology for Individuals with Disabilities Act of 2004 (Tech Act), which amended the previous Tech Act of 1998 to improve the provision of AT for individuals with disabilities. Third, Edmonds et al. (2009) conducted a meta-analysis on reading intervention for struggling adolescents students in Grades 6-12 between 1994 to 2004. Similarly, Edyburn (2004) conducted a literature review of studies on AT between 1999-2003.

The initial search was conducted using a combination of broader terminologies such as “assistive technology and reading” or “computer aided learning and reading.” These searches led to over 300 articles each from the various databases. Therefore, the search terms were refined to a combination of more specific terminologies. The search with “text-to-speech and reading”
yielded 36 articles in PsycInfo, 45 for JSTOR, 21 for ERIC, 46 for Academic Search Premier. When further refined to include “secondary school/high school/middle school” or “reading intervention,” the results were small ranging from one to 13 with all articles found under this search included in the keyword search with “text-to-speech and reading.” Ancestral and hand searches led to two additional articles not found in the database searches. After reviewing 48 articles found by the database, ancestral, and hand searches, seven articles met the criteria for inclusion and exclusion in the synthesis.

Results

This section reports on the results of the literature synthesis. The results are summarized in two tables. Table 1 provides information on demographics and setting to provide context of the seven studies. Table 2 summarizes the study design; independent and dependent variables; intervention procedures; and the key findings for the seven studies reviewed. Information provided in Table 1 and 4 are pertinent in answering the research questions.

Summary of Subject Demographics

Study sample size ranged from 2 to 93 students with a combined total of 169 student participants amongst the seven studies. There were slightly more males than females when gender was reported; in total, the ratio of male to female students was 7:6. Only one of the seven studies focused on high school participants (Izzo, Yurick & McArrell, 2009). Lange, McPhillips, Mulhern and Wylie’s (2006) study may also be all considered as high school students in the U.S., but since their study took place in Northern Ireland, the specific grade level cannot be determined. Their participants’ age ranged from 14.5 to 15.8 year olds, which is most likely equivalent of students in 9th and 10th grade in the U.S. Five of the seven studies indicated participants’ disability status and category. These included students with LD, reading disabilities,
and emotional disabilities. Two studies did not indicate specific disability type, but identified the participants as remedial readers (Schmitt, Hale, McCallum & Mauck, 2011) or reading at least one grade below (Lange et al., 2006). Ethnicity varied when indicated, but the majority were Caucasian.

**Study Locations**

Five of the seven studies took place in the U.S.; one was in Ontario, Canada (Black, 2011), and the other in Belfast, Northern Ireland (Lange et al., 2006). All studies took place within a school setting; the types of school varied from a private day school to public schools in cities or rural area.

**Research Questions**

**Research question 1.** What types of TTS software and associated tools were used for intervention to improve reading of struggling readers in secondary school?

All but one study (Black, 2011) identified the TTS software used in the study. Four of the studies used what is classified as a comprehensive TTS software such as Kurzweil 3000 and Read and Write Gold. Three studies used Kurzweil 3000 (Miller & Zahner, 2004; Schmitt et al., 2011; Schmitt, McCallum, Hale, Obeldobel & Dingus, 2009). One used Read and Write Gold, Version 6 (Lange et al., 2006). Moorman et al., 2010 used Read Please 2003, which is a single-function product (Elkind & Elkind, 2007). Finally, Izzo et al. (2009) used CLiCk, Speak TTS (CLiCk, Speak, 2008), which is a free, open source extension for the Firefox web browser. Although Black (2011) in her study did not name the TTS software used, the author indicated it was a TTS software with a highlighting feature and a choice of voice and reading speed.

**Research question 2.** How was the TTS software implemented to improve reading of struggling readers in secondary school?
The setting in which the study was implemented, study design, study variables, and procedures all provide insights into how TTS was implemented in each of the studies. The setting is summarized in Table 1 and variables and procedures are summarized in Table 2.

**Research Design.** Three studies utilized a single-case subject design (Izzo et al., 2009; Moorman et al., 2010; Schmitt et al., 2009). Black (2011) used a mixed-methods design with quantitative study first for six weeks followed by a qualitative study using a semi-structured interview with the participating students and a focus group with the teachers. Similarly, Miller & Zhaner (2004) used a mixed-methods design utilizing quantitative measures to measure reading outcomes and qualitative design to conduct student interviews and observations. They conducted interviews with the participant on a weekly basis for the four weeks of intervention period (Miller & Zhaner, 2004). Schmitt et al. (2011) conducted a two-way within subject and repeated measures design. Lange et al. (2006)’s study was a two-factor mixed design with pre test-training-post test design.

**Duration of the Intervention.** The duration of the intervention ranged from as short as two days of TTS use to 14 weeks of use. The most common duration was six weeks followed by four weeks. However, no specific dosage (minutes) of use of TTS software was reported for all seven studies. It is unclear how much time each participants actually utilized the TTS software.

**Implementation.** There were two distinct ways in which TTS was implemented in the studies. The first way was integrating the use of the TTS software with the class curriculum. Three of the studies incorporated such use of the TTS software (Black, 2011; Izzo, et al., 2009; Miller & Zahner, 2004). In this case, students were asked to use the TTS software to access (read) reading materials, answer questions, or complete assignments from grade level text, such
as World Economics and Life Science. In addition, the teachers were trained on the use of the TTS software to facilitate the use within the classroom with the students.

The second mean of implementation was using the TTS software outside of a regular classroom curriculum and setting with researcher and researcher provided materials (Lange et al., 2006; Moorman et al., 2010; Schmitt et al., 2011; Schmitt et al., 2009). In these cases, the researchers worked directly with the participants. Participants were pulled out of a class during or after school to use a school computer lab or an empty classroom to use the TTS software. Participants were asked to read materials prepared by the researchers. These materials were grade level reading material or participant reading level materials.

**Research question 3.** How are reading comprehension outcomes measured (e.g. instruments, formats, with or without the use of TTS)?

Although all studies included some form of reading comprehension as the dependent measure, the measures varied from study to study. Specific dependent measures are outlined in Table 2.

*Instruments and Format.* Four of the studies used multiple choice answer formats to test reading comprehension. Of the four studies, two studies by Schmitte et al. (2009 & 2011) used Timed Readings in Literature (Spargo, 1998) series; Izzo et. al (2009) study used AIMSweb curriculum based measurement as well as unit quizzes and tests from the textbook used for the class. Lange et al. (2006) adapted the Wechsler Objective Reading Dimensions Basic Reading subtest and Neale Analysis of Reading Ability II as a multiple-choice test on a computer. Other studies assessed reading comprehension through writing or through oral response. Black (2011) used Ontario Comprehension Assessment, which required the students to answer questions in a written format. Miller & Zahner (2004) used a standardized test, Kauffman Test of Educational
Achievement, which measured comprehension by having students respond orally or gesturally to commands given in printed statements. Finally, Moorman et al.’s (2010) study had 20-point reading comprehension questions, which were asked orally by the researcher and answered orally by the students. As can be seen, reading comprehension measures varied significantly across studies although short multiple-choice tests were most common.

Testing Outcomes With or Without TTS. Reading comprehension was measured with and without TTS (see Table 2). The majority of the studies focused on student reading comprehension improvement while using the TTS software. This includes the single subject studies in which the intervention conditions were with the use of the TTS software. Only two of the seven studies (Miller & Zhaner, 2004; Izzo et al., 2009) tested students on their reading comprehension pre- post- without the use of the TTS software to see the effect of the TTS software intervention when the tool was not used (remediation effect).

Research question 4. What were the reading comprehension outcomes of struggling readers in secondary school who use TTS?

Six of the seven studies reported gains or improvements in reading comprehension. Lange et al. (2006) reported significant improvements in reading comprehension for the TTS group ($t(30) = 3.14$, $p < .005$) in comparison to the control group without the use of the TTS software. Izzo et al.’s (2009) participants as a group had increased unit quiz and reading comprehension performance with the use of TTS software with a large effect size of .88 for unit quizzes and an effect size of 1.3 for overall reading comprehension performance. Moorman et al. (2010) reported 9% increase in reading comprehension for the participants with the use of TTS in comparison to without the use of TTS. Black (2011) reported improvements in the participants’ reading comprehension from pre to post test, but no specific information on the amount of gain
was reported. This was the same for Miller & Zahner (2004). They reported 80% of their participants performed better on the post test than pre test on the standardized test but no gains on weekly test scores; they did not report the amount of gain or the significance of the gain. Schmitt et al. on their earlier study (2009) using participants’ performance level reading passages showed gains in reading comprehension accuracy and rate with effect size ranging from 0.37 to 1.17 across participants. However, on their 2011 study, which used grade level passages, no significant difference were seen with the comprehension accuracy between the use of TTS, and without (t(24) = .93, p = .36).

Discussion

The primary purpose of the current review was to examine current research studies on the effectiveness of the TTS software in improving reading comprehension outcome of secondary struggling readers. Consistent with the past studies, results on the effectiveness of the TTS software upon improving the reading comprehension outcomes were mixed, but there is a potential in improving reading comprehension of students with disabilities or those who are struggling readers in secondary school. The finding is consistent with previous studies, prior to 2004, of secondary students as well as postsecondary students (Elkind & Elkind, 2007). The mixed results of the effectiveness seem to stem from many reasons, including the types of TTS used, sample characteristics, differences in implementation, and differences in how reading is measured.

Comprehensive versus Simple TTS Software

There are many comprehensive TTS software such as Kurzweil 3000 and Read &Write Gold. Often, these comprehensive TTS products include features such as highlighting of the words being read, choices of voice and speed, and study tools such as a dictionary, sticky notes,
and footnotes. In the current review, all of the studies except the one by Izzo et al. (2009) used a TTS software that have tools and features that are more than a simple speech synthesis. However, very few studies made clear what features and tools of comprehensive TTS were used aside from the speech synthesis. When specified, studies utilized the highlighting feature along with the speech synthesis. This bimodal aspect of a comprehensive TTS (i.e. visual tracking of the text with a highlighter and hearing of the words through speech synthesis simultaneously) is consistent with the past studies which have shown to improve word recognition and reading comprehension (Disseldorp & Chambers, 2002; Elkind et al., 1996; Elkind et al., 1993; Shany and Biemiller, 1995; Hecker, Burns, Katz & Elkind, 2002; Leong, 1995; Higgins & Raskind, 1997). With various types of TTS software available commercially, it is important to begin to review the specific features and tools used by the students. As suggested by Moorman et al. (2010), there is a need to investigate which product will have the greatest impact on various learners. Further, a study similar to Lange et al. (2006), where specific components of TTS software are investigated, will be needed to find out what aspects of comprehensive TTS software are contributing to improvements in reading.

Investigating specific types and component of the TTS software is important, but the results of this synthesis indicate that there also needs to be clarification on how TTS software is used and how reading comprehension is tested. As seen from the results, the TTS software was incorporated within a regular curriculum or used outside of the classroom with the researcher. The use of the TTS software with grade level materials within the regular classroom is an important aspect to consider especially for secondary students because students often do not have additional time to be pulled out for a targeted intervention in reading (Faggella-Luby & Deshler, 2008). Such use of the TTS software, within the classroom, will provide struggling secondary
level readers with access to their materials used within the classroom as well as the potential to improve reading comprehension. Thus, the TTS software can have a dual purpose: (1) an AT that can be integrated as an accommodation or a compensatory tool; and (2) a remediation tool to augment reading skills. Only one study (Miller & Zhaner, 2004) really looked at the dual purpose of the TTS software although the researchers did not differentiate the two purposes. Other studies reviewed the effectiveness of the TTS software only as an accommodation tool and examined whether students improved their reading comprehension while using the software. The dual purpose of the TTS software is also aligned with the RTI initiatives and aligned with the Universal Design for Learning principles where a small group or technology enhanced interventions are provided within the general education classrooms. Having the TTS software investigated with the use of curriculum also afford the opportunities for the teachers to be the trained. In Black’s (2011) study, the teachers received intensive training on the use of TTS software and became confident in incorporating the use of TTS within their classroom practice. On the contrary, Miller and Zahner (2004) reported that two-thirds of the teachers was unsure about TTS software use with the students as they were not fully trained. Use of teachers as agents need to be considered in the future studies.

Finally, in further determining the effectiveness of TTS software as an accommodation and as a remediation tool, there may need to be two types of reading comprehension tests with both administered with the use of TTS software and without the use of TTS software. The two forms of reading tests could be a curriculum based measurement (CBM) to investigate the effectiveness of TTS software as an accommodation tool and a standardized norm referenced test to test the effectiveness of TTS software as a remediation tool. None of the studies reviewed used both a CBM and a standardized norm referenced test. Izzo et al.’s (2009) assessed reading
comprehension improvements using multiple measures (i.e., CBM and unit quizzes and tests). They tested the students with TTS for the unit quizzes and tests and without TTS for the AIMWeb CBM. Participants in their study only showed improvements with the use of TTS as an accommodation tool, but no change was seen on their reading level as measured on CBM. More studies that include more than one measure of reading comprehension tests would be needed. Furthermore, the majority of the studies reviewed used only a few multiple choice reading tests to assess students’ reading comprehension, thus a more sensitive reading test, that includes retell, is needed to measure change in reading skills.

**Conclusion and Future Directions**

Overall, this literature review synthesis showed a positive trend when a TTS software was used in improving reading comprehension of secondary students who are struggling readers, but not a clear effectiveness. However, evidence is limited as it only included seven studies. Although it is difficult to draw conclusion, it is evident that there is still a need for more controlled and systematic studies in finding the effectiveness of TTS software on reading comprehension of struggling readers in secondary school. Future studies should include and track all of the components of TTS software used by the participating students. Such component analysis will help determine what types of TTS software is most effective for secondary school students and it would help practitioners in determining which TTS software to use with their students. Another recommendation is to test students’ reading with and without the use of TTS using both grade level and performance level reading materials to see the effects of TTS software as a compensatory tool or a remediation tool. Additionally, future studies should specify how and how long students and also teachers are trained to use TTS software and whether there is any differential effect on students’ reading comprehension based on the training method. Finally,
studies should investigate long-term maintenance effect of the use of TTS software on reading comprehension but also on students’ attitudes and perceptions towards reading.
References


www.all4ed.org/files/HighCost.pdf


http://www.all4ed.org/publication_material/reports


<table>
<thead>
<tr>
<th>Author(s)</th>
<th>n</th>
<th>M/F</th>
<th>Grade(s)</th>
<th>Disability Type (s)</th>
<th>Ethnicity</th>
<th>Reading Level Before Intervention</th>
<th>School Type/ Location/ Size</th>
<th>Class Setting/ Curriculum</th>
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<tr>
<td>Black, 2011</td>
<td>8</td>
<td>5/3</td>
<td>All Gr. 8</td>
<td>All LD</td>
<td>Not indicated</td>
<td>Ontario Comprehension Assessment used, but scores not indicated</td>
<td>JK-8/Urban Southern Ontario, Canada /700 students</td>
<td>3 grade 8 classes / Literacy</td>
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<td>Izzo, Yurick, &amp; McArrell, 2009</td>
<td>7</td>
<td>3/4</td>
<td>1- Gr. 9 1- Gr. 10 3- Gr. 11 2- Gr. 12</td>
<td>1 TBI; 3 Cognitive disability; 1 Autism; 1- ED; 1 LD</td>
<td>7 Caucasian</td>
<td>6 intensive (below-grade level) &amp; 1 strategic level (non-reader) based on AIMSWeb Maze</td>
<td>High School/ Small city in Midwest U.S. / 3,000 students</td>
<td>English Resource/ Envision IT Curriculum</td>
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<td>Lange, McPhillips, Mulhern &amp; Wylie, 2006</td>
<td>93</td>
<td>47/46</td>
<td>Age 14.5 – 15.8</td>
<td>No-diagnosis</td>
<td>92 Anglo 1 Other</td>
<td>Reading age range (yrs/mos) 7.3 - 14.0 M=10.0 in treatment group; based on the WORD subtest &amp; Neale Analysis of Reading Ability II</td>
<td>Secondary level schools/ Belfast, Northern Ireland /Not indicated</td>
<td>Pull-out / Researcher made material</td>
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Table 1 (Continued)

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<th>Author(s)</th>
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<th>Ethnicity</th>
<th>Reading Level Before Intervention</th>
<th>School Type/Location/Size</th>
<th>Class Setting/Curriculum</th>
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<td>Miller &amp; Zahner, 2004</td>
<td>30</td>
<td>-</td>
<td>All Gr. 7</td>
<td>15 – LD; 15 – no disability</td>
<td>Not indicated</td>
<td>Kauffman Test of Educational Ability Brief used but scores not indicated</td>
<td>Middle School/Rural Northeast Georgia U.S. / 766</td>
<td>7th grade /Life Science</td>
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<tr>
<td>Moorman, Boon, Keller-Bell, Stagliano, &amp; Jeffs, 2010</td>
<td>2</td>
<td>1/1</td>
<td>1- Gr. 9</td>
<td>1 LD in Reading; 1 LD in Reading &amp; Math</td>
<td>All Caucasian</td>
<td>4.0 to 5.1 grade level based upon standardized scores</td>
<td>Public High School in Southeast U.S. / not indicated</td>
<td>Pull-out by researcher / Researcher made material</td>
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<tr>
<td>Schmitt, Hale, McCallum &amp; Mauck, 2011</td>
<td>25</td>
<td>15/10</td>
<td>6 - Gr. 6</td>
<td>No-diagnosis</td>
<td>15 Caucasian; 6 Af. Am; 2 Hispanic; 2 Multi-Cultural</td>
<td>1.0 to 5.0 grade level based on Scholastic Reading Inventory and Read 180</td>
<td>Southeastern U.S. / Not indicated</td>
<td>Pull-out by researcher / Timed Reading Series</td>
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<tr>
<td>Schmitt, McCallum, Hale, Obeldobel &amp; Dingus, 2009</td>
<td>4</td>
<td>3/1</td>
<td>2-13 year olds; 15 year old; 16 year old</td>
<td>Reading disability &amp; ED</td>
<td>3 African American; 1 Caucasian</td>
<td>Significantly below grade level to early elementary level</td>
<td>Private-placement day school in mid-Atlantic U.S.</td>
<td>Pull-out by researcher/ Timed Reading Series</td>
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Notes. n=sample size LD = Learning Disability M/F = Male/Female RD= Reading Disability Gr.= Grade ED=Emotional disturbance WORD=Wechsler Objective Reading Dimensions Basic Reading subtest Af. Am. = African American
## Table 2

*Variables, Procedures and Findings*

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Research Design</th>
<th>Independent Variable (TTS)</th>
<th>Dependent Variable(s)</th>
<th>Procedures</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, 2011</td>
<td>Mixed-methods/ 1.pre-post tests &amp; 2.semi-structured interviews 3.focus groups</td>
<td>Text-to-voice/Word prediction - nonspecified</td>
<td>Ontario Comprehension Assessment (OCA) (Reading comprehension as measured through writing)</td>
<td>6 weeks</td>
<td>Teachers received on &amp; off-site PD 1 month prior to using TTS Tested using TTS to write answers Improvement in reading comprehension as measured through OCA assessment scores.</td>
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<tr>
<td>Izzo, Yurick, &amp; McArrell, 2009</td>
<td>Single-subject reversal design</td>
<td>CLiCk, Speak TTS screen reader software</td>
<td>8th grade AIMSweb Maze Reading Comprehension Assessments; Envision IT Curriculum Unit quizzes &amp; comprehension assessments;</td>
<td>14 weeks for 3x/week within 80 minutes class</td>
<td>First 1-3 units to familiarize with the program and unit quizzes Protocol &amp; Training /Fidelity checklist used Tested without the use of TTS for AIMSweb Maze; Tested with TTS on Unit quizzes &amp; tests Unit quizzes and reading comprehension assessments increased with large effect size (.88 and 1.3). Reading levels on AIMSweb did not change.</td>
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<th>Procedures</th>
<th>Findings</th>
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<tr>
<td>Miller &amp; Zahner, 2004</td>
<td>Action research 1. Pre/post test 2.observation &amp; field notes 3. weekly student interviews 4. survey</td>
<td>Kurzweil 3000</td>
<td>1.Reading skills as measured on KTEA Brief (decoding &amp; comprehension) 2. Student attitudes 3. Teacher attitudes</td>
<td>4 weeks for 3x/week within 75 minutes class</td>
<td>Practice and training while Taking tests, completing workbooks and preparing study guides</td>
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<th>Author(s)</th>
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<th>Findings</th>
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<tr>
<td>Moorman, Boon, Keller-Bell, Stagliano, &amp; Jeffs, 2010</td>
<td>Single-subject ABAB withdrawal</td>
<td>ReadPlease version 2003</td>
<td>1. Reading rate; 2. Reading comprehension accuracy; 3. Student survey (social validity)</td>
<td>4 weeks 2-6 sessions / week Each session = 1 reading passage</td>
<td>Tested using TTS during intervention condition Comprehension questions answered orally without TTS</td>
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<tr>
<td>Schmitt, Hale, McCallum &amp; Mauck, 2011</td>
<td>Quasi-experimental 1. Within-subjects, 2-way ANOVA; 2. Repeated-measures ANCOVA</td>
<td>Kurzweil 3000, Version 10</td>
<td>Reading comprehension questions from <em>Timed Reading Series Plus</em> Grades 6-8 (factual &amp; inferential) correctly answered</td>
<td>2 days</td>
<td>Tested using TTS for reading passages Comprehension questions answered without TTS</td>
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<th>Author(s)</th>
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<th>Procedures</th>
<th>Findings</th>
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<tr>
<td>Schmitt, McCallum, Hale, Obeldobel &amp; Dingus, 2009</td>
<td>Single-subject adapted alternating-treatment design</td>
<td>Kurzweil 3000, Version 10</td>
<td>1. Reading comprehension questions from <em>Timed Reading Series Plus</em> Grade 4 2. Reading Comprehension rate</td>
<td>10 days 20 minutes per day for all 3 intervention conditions (TTS, listening, silent reading)</td>
<td>Not indicated Tested using TTS during intervention condition Comprehension questions answered without TTS Across participants, TTS (listening while reading) condition resulted in greater comprehension accuracy compared to listening or silent reading. Effect size ranged from 0.37 to 1.17 For 3 of the 4 participants, TTS condition resulted in greater comprehension rate with effect size ranging from 0.30 to 1.12</td>
</tr>
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*Notes.* WORD = Wechsler Objective Reading Dimensions Basic Reading subtest KTEA = Kaufman Test of Educational Achievement
Your Project Assigned Number: ___________________________ Date: ______________

Name of School: _____________________________________________________________________________________

Name of Teacher: _____________________________________________________________________________________

1. What is your gender?  □ Male  □ Female  
2. What is your age? __________

3. What is your ethnicity? (Select all that apply)
   □ Hawaiian / Part-Hawaiian  □ Chamorro  □ Filipino  □ Samoan
   □ Caucasian/White  □ African American  □ Hispanic/Latino  □ Portuguese
   □ Japanese  □ Chuukese  □ Chinese  □ Korean
   □ Vietnamese  □ Other __________________________________________________________________________

4. What language(s) do you use at home? _________________________________________________________________

5. Do you have an IEP or a 504 plan?
   □ Yes  □ No

   If yes, what is your disability? (Select all that apply)
   □ I don’t know
   □ Asperger’s Syndrome/Autism Spectrum Disorder
   □ Attention Deficit Disorder (ADD)
   □ Attention Deficit Hyperactivity Disorder (ADHD)
   □ Deaf or Hard-of-Hearing
   □ Physical Impairment/Orthopedic/Mobility Impairment
   □ Systemic Health/Medical Condition
   □ Psychological/Psychiatric Condition
   □ Learning Disorder
   □ Blind or Visual Impairment
   □ Speech Impairment
   □ Acquired/Traumatic Brain Injury
   □ Other (Please specify: ________________________________________________________________)

6. Before this class, have you used computer technology to help you read?
   □ Yes  □ No

7. How much time do you usually spend reading for school per day?
   □ 0-9 min  □ 10 - 29 min  □ 30 – 59 min  □ 1 - 2 hours  □ Over 3 hours
8. How much time do you usually spend reading for enjoyment per day (i.e., magazines, books, newspaper, & Internet (including Facebook))?
   - 0-9 min
   - 10 - 29 min
   - 30 – 59 min
   - 1 - 2 hours
   - Over 3 hours

9. Do you think you are going to pass this class?
   - Definitely
   - Likely
   - Don’t Know
   - Unlikely
   - Never

10. Do you think you will graduate from high school with a regular diploma?
    - Definitely
    - Likely
    - Don’t Know
    - Unlikely
    - Won’t Graduate

11. What is the highest academic degree you want to obtain?
    - High school diploma
    - High school certification
    - Vocational Certificate
    - Associate’s (graduate from community college)
    - Bachelor’s (graduate from a 4-year college)
    - Master’s (graduate school)
    - Doctoral/ Professional (graduate school)
    - Other (Please specify: ____________________________)

12. Read the following sentences¹ and circle your response using the 5-point scale.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think I am pretty good at reading.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I learn new words easily.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I remember the important points in readings very well.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I have no problem learning reading skills.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>If I can’t understand a reading the first time, I keep trying until I can.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>One of my main goals is to be much better at reading by next year.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I can motivate myself to read.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I avoid trying to read new articles when they look too difficult to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I find a lot of readings hard to understand.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

¹ The sentences were selected from Adult and ESL Literacy Learning Self-Efficacy Questionnaire, Mikulecky, Lloyd, & Huang (1996).
My reading assignments worry me.  

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Reading is boring.  

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

13. Do you think the use of computer assisted technology for reading can help improve the following? Circle your response using the 5-point scale.

<table>
<thead>
<tr>
<th>Never</th>
<th>Unlikely</th>
<th>Neutral</th>
<th>Likely</th>
<th>Definitely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Access to reading materials (being able to read books and other materials that are usually too difficult for me)

Vocabulary

Reading Comprehension

Reading rate (speed in which I read)

Grade in this class.

Class Attendance in this class.

Staying in school next semester.

Pursuing graduation from high school.

14. How much do you think reading is important for completing this class?

☑ Very Important ☐ Important ☐ Don’t know ☐ Not Important ☐ Not At All Important

Thank You for Completing the Survey.
Steppingstones: Phase 2 Text-to-Speech Study
Student Post-Survey

Your Project Assigned Number: ___________________________ Date: ____________

Name of School: _______________________________________________________________________________________

Name of Teacher: _______________________________________________________________________________________

1. During this semester how much time did you spend reading for this class per day?
   - 0 - 9 min   - 10 - 29 min   - 30 – 59 min   - 1 - 2 hours   - Over 3 hours

2. During this semester how much time did you spend reading for enjoyment per day (i.e., magazines, books, newspaper, & Internet (including Facebook)?)
   - 0 - 9 min   - 10 - 29 min   - 30 – 59 min   - 1-2 hours   - Over 3 hours

3. Do you think you are going to pass this class?
   - Definitely   - Likely   - Don’t Know   - Unlikely   - Never

4. Do you think you will graduate from high school with a regular diploma?
   - Definitely   - Likely   - Don’t Know   - Unlikely   - Won’t Graduate

5. What is the highest academic degree you want to obtain?
   - High school diploma
   - High school certification
   - Vocational Certificate
   - Associate’s (graduate from community college)
   - Bachelor’s (graduate from a 4-year college)
   - Master’s (graduate school)
   - Doctoral/ Professional (graduate school)
   - Other (Please specify: _________________________________________________________________)
6. Read the following sentences and circle your response using the 5-point scale.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think I am pretty good at reading.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I learn new words easily.</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I remember the important points in readings very well.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I have no problem learning reading skills.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>If I can’t understand a reading the first time, I keep trying until I can.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>One of my main goals is to be much better at reading by next year.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I can motivate myself to read.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I avoid trying to read new articles when they look too difficult to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I find a lot of readings hard to understand.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>My reading assignments worry me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Reading is boring.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

STOP here, if you did not use Kurzweil software this semester.
ANSWER questions 7 to 11, if you used Kurzweil software this semester.

---

1 The sentences were selected from Adult and ESL Literacy Learning Self-Efficacy Questionnaire, Mikulecky, Lloyd, & Huang (1996).
7. Do you think the use of computer assisted technology for reading help improve the following? Circle your response using the 5-point scale

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Unlikely</th>
<th>Neutral</th>
<th>Likely</th>
<th>Definitely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to reading materials (being able to read books and other materials that are usually too difficult for me)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Reading rate (speed in which I read)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Grade in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Class Attendance in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Staying in school next semester.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Pursuing graduation from high school.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

8. To what extent, were you satisfied with the use of Kurzweil software for reading?

- [ ] Highly Satisfied
- [ ] Satisfied
- [ ] Neutral
- [ ] Dissatisfied
- [ ] Highly Dissatisfied

9. What did you like **most** about using the Kurzweil software?

10. What did you like **least** about using the Kurzweil software?

11. Would you use the Kurzweil software again?

- [ ] Definitely
- [ ] Likely
- [ ] Neutral
- [ ] Unlikely
- [ ] Never

Thank You for Completing the Survey.
Teacher Pre-Survey (Intervention Group)

Your Initials: ___________________________                      Date: ____________________

Name of School: ______________________________________________________________

1. What is your gender?
   □ Male  □ Female

2. In what class/subject will you use the Kurzweil software?

3. How many years have you been teaching this subject (from number one)?

4. How many years have you been teaching high school students?

5. Are you certified to teach this subject (from number one)?
   □ Yes  □ No

6. On average, how much time is usually spent on reading activities (e.g., vocabulary building, comprehension, silent reading, and/or group reading) in one class period?
   □ 0-5 min  □ 6 - 10 min  □ 11 – 20 min  □ 21-30 min  □ Over 31 min

7. Before this class, have you used computer assisted technology when teaching this subject?
   □ Yes       □ No
8. How important do you think are reading skills instruction in order for students to… Circle your response using the 5-point scale.

<table>
<thead>
<tr>
<th></th>
<th>Not at all important</th>
<th>Not important</th>
<th>Don’t know</th>
<th>Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access class reading materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improve vocabulary</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improve reading Comprehension</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improve reading rate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Obtain A or B grade in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Attend this class on a regular basis.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Remain in high school.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Be able to graduate from high school.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

9. Do you think the use of computer assisted technology for reading can help improve the following? Circle your response using the 5-point scale.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Unlikely</th>
<th>Neutral</th>
<th>Likely</th>
<th>Definitely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students’ access to reading materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ vocabulary</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ reading Comprehension</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ reading rate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ grade in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ class attendance in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Students’ retention rate in school. | 1 | 2 | 3 | 4 | 5
---|---|---|---|---|---

Students’ graduation rate. | 1 | 2 | 3 | 4 | 5
---|---|---|---|---|---

10. What is your typical teaching method for this class (i.e., discussion, lecture, other teaching strategies, materials, and use of technology)?

Thank You for Completing the Survey.
Steppingstones: Phase 2 Text-to-Speech Study
Teacher Post-Survey

Your Initials: ___________________________                      Date: ____________________
Name of School: ______________________________________________________________

1. How much time did you spend preparing for this class for each class session?
   - 0-5 min
   - 6 - 10 min
   - 11 – 20 min
   - 21-30 min
   - Over 31 min

2. What instructional method(s) did you use to teach this class during this semester (i.e., discussion, lecture, other teaching strategies, materials, and use of technology)?

3. On average, how much time did you spend teaching reading skills (e.g., vocabulary building, comprehension, silent reading, and/or group reading) in this class during this semester?
   - 0-5 min
   - 6 - 10 min
   - 11 – 20 min
   - 21-30 min
   - Over 31 min

4. Do you think reading skills instruction in this class had impact on students to… (Circle your response using the 5-point scale.)

<table>
<thead>
<tr>
<th></th>
<th>Not at all important</th>
<th>Not important</th>
<th>Don’t know</th>
<th>Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access class reading materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improve vocabulary</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improve reading rate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Obtain A or B grade in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Attend this class on a regular basis. | 1 | 2 | 3 | 4 | 5
---|---|---|---|---|---
Remain in high school. | 1 | 2 | 3 | 4 | 5
---|---|---|---|---|---
Be able to graduate from high school. | 1 | 2 | 3 | 4 | 5
---|---|---|---|---|---

STOP here, if you did not use Kurzweil software this semester.
ANSWER question 5 to 9, if you used Kurzweil software this semester.

5. Do you think the use of computer assisted technology for reading helped improve the following? Circle your response using the 5-point scale.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Unlikely</th>
<th>Neutral</th>
<th>Likely</th>
<th>Definitely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students’ access to reading materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ vocabulary</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ reading Comprehension</td>
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<td>2</td>
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<td>2</td>
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<tr>
<td>Students’ grade in this class.</td>
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<td>Students’ class attendance in this class.</td>
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<td>5</td>
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<tr>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Students’ graduation rate.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

6. To what extent, were you satisfied with the use of Kurzweil software for reading with the intervention class?
   -  □ Highly Satisfied   -  □ Satisfied   -  □ Neutral   -  □ Dissatisfied   -  □ Highly Dissatisfied

7. What did you like **most** about using the Kurzweil software in teaching your class?
8. What did you like least about using the Kurzweil software in teaching your class?

9. Would you use the Kurzweil software again?
   - Definitely
   - Likely
   - Neutral
   - Unlikely
   - Never

Thank You for Completing the Survey.
## Appendix F
### Kurzweil Log

<table>
<thead>
<tr>
<th>Action</th>
<th>Code</th>
<th>Category</th>
</tr>
</thead>
<tbody>
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<td></td>
</tr>
<tr>
<td>File Saved</td>
<td>401</td>
<td></td>
</tr>
<tr>
<td>File Created</td>
<td>402</td>
<td></td>
</tr>
<tr>
<td>File Exported</td>
<td>403</td>
<td></td>
</tr>
<tr>
<td>File Exported with Range</td>
<td>404</td>
<td></td>
</tr>
<tr>
<td>Files Merged</td>
<td>405</td>
<td></td>
</tr>
<tr>
<td>File Sent</td>
<td>406</td>
<td></td>
</tr>
<tr>
<td>File Closed</td>
<td>407</td>
<td></td>
</tr>
<tr>
<td>Extract To Column Notes</td>
<td>408</td>
<td>Study Skills</td>
</tr>
<tr>
<td>Extract Markup</td>
<td>409</td>
<td>Study Skills</td>
</tr>
<tr>
<td>Extract Text</td>
<td>410</td>
<td>Study Skills</td>
</tr>
<tr>
<td>Extract Column Notes to Outline</td>
<td>411</td>
<td>Study Skills</td>
</tr>
<tr>
<td>File Printed</td>
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<td></td>
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<tr>
<td>Audio File Created</td>
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<td>Document Context Changed</td>
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<td></td>
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<tr>
<td>Reading Voice Changed</td>
<td>415</td>
<td>Reading</td>
</tr>
<tr>
<td>Reading Speed Changed</td>
<td>416</td>
<td>Reading</td>
</tr>
<tr>
<td>Reading Started</td>
<td>417</td>
<td>Reading</td>
</tr>
<tr>
<td>Reading Ended</td>
<td>418</td>
<td>Reading</td>
</tr>
<tr>
<td>Page Turned</td>
<td>419</td>
<td>Reading</td>
</tr>
<tr>
<td>Look Up Definition</td>
<td>420</td>
<td>Dictionary</td>
</tr>
<tr>
<td>Definition Not Found</td>
<td>421</td>
<td>Dictionary</td>
</tr>
<tr>
<td>Look Up in Encarta</td>
<td>422</td>
<td>Dictionary</td>
</tr>
<tr>
<td>Get Synonyms</td>
<td>423</td>
<td>Dictionary</td>
</tr>
<tr>
<td>Synonyms not Found</td>
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<td>Hear Syllables for Word</td>
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<td>Scan a Page</td>
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<td>Optimize Scanning</td>
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<td>Two Page Mode</td>
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<td>Color Scanning</td>
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<td>Double Sided</td>
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<td>Zone Editor Invoked</td>
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<tr>
<td>Corrections Dialog Visited</td>
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<td>Read Silently</td>
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<td>Use Highlighter</td>
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<td>Add Voice Note</td>
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<td>Add Footnote</td>
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<td>Add Sticky Note</td>
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<tr>
<td>Add Bubble Note</td>
<td>452</td>
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<tr>
<td>Add Text Note</td>
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<td>Highlight with Word List</td>
<td>454</td>
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<tr>
<td>Search with Word List</td>
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<td>Open Bubble Note</td>
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<td>Dismiss Bubble Note</td>
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<td>Ranked Spelling Invoked</td>
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<td>Client invoked with Command Line</td>
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<td>Toolbar Set Applied</td>
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<td>Split Screen View</td>
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<td>Draft View</td>
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<td>Assignments Dialog Invoked</td>
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<td>Word Inserted from Word List</td>
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<td>Word Replaced from Word List</td>
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</table>

Reading
APPENDIX G

Steppingstones: Phase 2 Text-to-Speech Study

Class Observation Checklist

Date (MM/DD/YY): School: Teacher: 

Subject: Period: 

Group Assigned: Intervention Comparison 

Observers: 

Observation Starting Time: Observation Ending Time: 

1. **Class activities**: (Note. “TTS” in the table includes other reading software/technology.)

<table>
<thead>
<tr>
<th>Instructional Methods</th>
<th>Yes</th>
<th>No</th>
<th>Frequency of Occurrence</th>
<th>Average Duration of Activity (in Minutes)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary building activity</td>
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</tr>
<tr>
<td>Comprehension building activity (Questions, discussions, etc.)</td>
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</tr>
<tr>
<td>Explicit reading fluency building (Choral reading, echo reading, etc.)</td>
<td></td>
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</tr>
<tr>
<td>Student independent reading, not using TTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small group/pair reading, not using TTS</td>
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</tr>
<tr>
<td>Whole group reading, not using TTS</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Teacher reading to class, not using TTS</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student independent reading using TTS</td>
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<tr>
<td>Small group/pair reading using TTS</td>
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<tr>
<td>Whole group reading using TTS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Teacher reading to class using TTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of study skills, not using TTS (Note-taking, highlighting, chunking etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of study skills using TTS (Note-taking, highlighting, chunking etc)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Look up words in the dictionary, not using TTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Look up words in the dictionary, using TTS</td>
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<td></td>
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<tr>
<td>Read on-line resources/websites, not using TTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Read on-line resources/websites using TTS</td>
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<td></td>
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</tr>
<tr>
<td>Vocabulary assessment/Quiz (with or without the use of software)</td>
<td></td>
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<tr>
<td>Comprehension assessment/Quiz (with or without the software)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
2. List reading software/technology used for reading (if any)

3. List reading materials used (i.e., textbook, online resources, newspapers, journal articles, power points):

4. Student engagement in reading:

   The number of students on task all the time ( ___ out of ___ )
   The number of students on task more than half the time ( ___ out of ___ )
   The number of students on task less than half the time ( ___ out of ___ )

For the Intervention Group Only

I. Teacher-Directed use of Kurzweil for reading with a whole class:
1. Assists students to log-on: ☐ Yes ☐ No

2. Assists students in opening documents: ☐ Yes ☐ No

3. Use of reading tools (check all that apply)
   ( ) Adjust reading speed
   ( ) Adjust reading pace
   ( ) Adjust voice
   ( ) Other, specify:

4. Use of study skills tools (check all that apply)
   ( ) Use the highlighter
   ( ) Use the circle tool
   ( ) Use sticky notes
   ( ) Use bookmarks
   ( ) Use foot notes
   ( ) Extract the annotations
   ( ) Other, specify:

5. Use of dictionary tools (check all that apply)
   ( ) Choose an appropriate dictionary
   ( ) Use the dictionary
   ( ) Other, specify:

6. Use of web browser reading tools
   ( ) apply the Web browser reading features to read online
   ( ) Other, specify:

7. Other tools/features (i.e., Scanning, Writing templates)
   ( ) Specify:
II. Student use of Kurzweil:

When you begin to observe, randomly choose one student and then force yourself to observe the student next to him or her (in front of, beside or behind) while the student is using the Kurzweil. Try not to observe the student who first caught your eye as this student may have drawn your attention with an unusual behavior.

1. Students log-on with username  □ Yes □ No

2. Independently open a document  □ Yes □ No

3. Use of reading tools (check all that apply)
   ( ) Adjust reading speed
   ( ) Adjust reading pace
   ( ) Adjust voice
   ( ) Other, specify:

4. Use of study skills tools (check all that apply)
   ( ) Use the highlighter
   ( ) Use the circle tool
   ( ) Use sticky notes
   ( ) Use bookmarks
   ( ) Use foot notes
   ( ) Extract the annotations
   ( ) Other, specify:

5. Use of dictionary tools (check all that apply)
   ( ) Choose an appropriate dictionary
   ( ) Use the dictionary
   ( ) Other, specify:

6. Use of web browser reading tools
   ( ) apply the Web browser reading features to read online
   ( ) Other, specify:

7. Other tools/features (ie. Scanning, Writing templates)
   ( ) Specify:

8. Students stayed logged-on until end of class (ie. Did not log-out early)  □ Yes □ No

III. Notes (Please note any unusual occurrence):
<table>
<thead>
<tr>
<th>Name</th>
<th>Most Like about TTS</th>
<th>Helped with Classwork</th>
<th>Least Liked about TTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terry</td>
<td>It reads to you.</td>
<td>I can get done faster and I can understand more.</td>
<td>Nothing.</td>
</tr>
<tr>
<td>Mia</td>
<td>It helps me pronounce the words I can’t say.</td>
<td>It helped me understand what they are.</td>
<td>I’ve only got to use it 1 a week.</td>
</tr>
<tr>
<td>Jesse</td>
<td></td>
<td>It helped me with picking out key points.</td>
<td>How it doesn’t read fluently.</td>
</tr>
<tr>
<td>Aiden</td>
<td>I don’t have to read it instead it just reads for me.</td>
<td>It kind of made me finish my work a bit faster.</td>
<td>Sometimes it goes weird when we use the web.</td>
</tr>
<tr>
<td>Kim</td>
<td>I don’t have to read it to myself because the computer reads it the words to you.</td>
<td>I find answers much faster.</td>
<td>The kurzweil sometimes doesn’t sign in.</td>
</tr>
<tr>
<td>John</td>
<td>It provided dictionary.</td>
<td>It help me to find the definition for the word I don’t know.</td>
<td>It’s hard to understand the reader.</td>
</tr>
<tr>
<td>Tren</td>
<td>The most I like is that they read it to us so we can understand what you say.</td>
<td>It help me because so I can understand more.</td>
<td>The least I like was their voice.</td>
</tr>
<tr>
<td>Cameron</td>
<td>I liked how it read to me.</td>
<td>It gave me the definition.</td>
<td>I don’t like the voice of the computer.</td>
</tr>
<tr>
<td>Vilma</td>
<td>The kurzweil reads the story to you.</td>
<td>By reading the story it helped me pronounce the words I couldn’t say.</td>
<td>I have hard time getting it in my head.</td>
</tr>
<tr>
<td>Tom</td>
<td>Nothing just irritating me. Don’t even know what they saying. Rather read a book instead of listenin</td>
<td></td>
<td>I liked nothing.</td>
</tr>
<tr>
<td>Hank</td>
<td>What I like most is that I did not have to read, it reads to me.</td>
<td>It help me a lot because it reads to me and sometimes I am really lazy to read.</td>
<td>The voices talking, sometimes you can’t understand.</td>
</tr>
<tr>
<td>Nobu</td>
<td>The logging in!</td>
<td>So much</td>
<td>The voice</td>
</tr>
</tbody>
</table>
REFERENCES


Curry, Nembhard, & Bradley, 2009


Hock, Brasseur, Deshler, Catts, & Marquis, 2005


Hutchison, D., & Styles, B. (2010). *A guide to running randomised controlled trials for educational researchers.* Slough, UK: NFER.


"Cognition and Instruction. 5 (4), 269-287.


doi:10.1080/10862960709336758


http://www.explainthatstuff.com/how-speech-synthesis-works.html


http://www.balancedreading.com/olderreaders.html

