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The effects of word prediction and text-to-speech on the writing process of translating

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THE EFFECTS OF WORD PREDICTION AND TEXT-TO-SPEECH ON THE WRITING PROCESS OF TRANSLATING

BY

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Abstract

The Effects of Word Prediction and Text-to-Speech on the Writing Process of Translating

The purpose of this study was to determine the effects of the combination of word prediction and text-to-speech software on the writing process of translating.

Participants for this study included 10 elementary and middle school students who had a diagnosis of disorder of written expression. A modified multiple case series was used to collect data over a three-week period. The participants were asked to describe in writing what was happening in a picture-based writing prompt. The participants responded in writing using a word processor software alone in the pretest condition and using a word processor in conjunction with the word prediction, text-to-speech software WordQ in the posttest condition.

The results provide support for the use of the word prediction and text-to-speech features in WordQ with students who have a diagnosis of disorder of written expression. The participants' written work was significant for having fewer spelling errors, increased syntactic maturity as measured by mean T-unit length and fewer overall words produced when using the WordQ software.

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The Effects of Word Prediction and Text-to-Speech on the Writing Process of Translating

Introduction

Background and Overview

Writing is recognized as a foundational skill that is necessary for success in academics and other facets of life (Graham & Perin, 2007; Kaustic, Colligan, Weaver, & Barbaresi, 2009). Hooper (2002) indicates that writing ability is linked to both literacy and performance on achievement tests. The practical importance of writing ability becomes evident in light of today's evolving job market. The jobs that today's students are preparing for will emphasize areas of electronic communication, requiring them to produce written documentation, technical reports, visual/text presentations, memoranda, and electronic messages (Graham & Perin, 2007).

Unfortunately, the limited number of children prepared to meet these requirements is a concern. In the United States, a significant number of children experience limited writing abilities. Evidence of this is reflected in the scores of the 2011 National Assessment of Education Progress (NAEP) writing exam. This examination of eighth and twelfth graders incorporated three types of writing (narrative, informative and persuasive), and translated the scores into four levels of achievement: below basic, basic, proficient, and advanced (National Center for Education Statistics, 2011). The results revealed that overall, 74% of public school 8th graders and 73% of 12th graders who took the exam scored at or below the basic level of achievement. A factor that contributes to students' writing problems is the presence of a disability. The scores on the NAEP writing exam for students who were identified as having disabilities were significantly lower than their non-disabled peers, with 95% of them scoring at or below the basic level of achievement (National Center for Education Statistics, 2011).

The U.S. Department of Education (2010) indicates that 13.4% of students receiving a public education have some form of disability. By far, the most commonly occurring diagnosis within this group is Specific Learning Disability (SLD). The Individuals with Disabilities Education Act (IDEA) defines SLD as:

> a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations, including conditions, such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia (IDEA, 20 U.S.C. §1401(a)).

This definition is broad in its scope, identifying a number of impaired skill areas and possible conditions. A benefit of a broad definition is that it incorporates a variety of issues impacted by learning disability. Its limitation is that it groups all students with learning disabilities into the same category, neither acknowledging their individual learning issues or support needs. Greater specificity in identifying and understanding learning disorders is provided by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR). It identifies four different types of learning disorders, including: Reading Disorder, Mathematics Disorder, Disorder of Written Expression, and Learning Disorder not Otherwise Specified (American Psychiatric Association, 2000). Among these, Disorder of Written Expression (DWE) has received increased attention in recent years from educators who wish to improve their understanding of DWE, and develop interventions that address it (Hooper, 2002).

DWE and the Writing Process

DWE is characterized by writing skills that are substantially below those expected based on chronological age, measured intelligence, and age-appropriate education (American Psychiatric Association, 2000). DWE has been identified as being more common than reading disorder, and twice as likely to occur in boys than in girls (Kaustic et al., 2009). Students with DWE experience a number of different problems related to writing.

Using the Cognitive Process Theory of Writing developed by Flower and Hayes (1981), students with DWE experience difficulty with the three primary processes associated with writing: planning, translating and reviewing.

Planning. Planning involves developing ideas and organizing a writing project (Flower & Hayes, 1981).

Translating. Translating is the process of converting ideas into visible language. Berninger (1999) amended the Flower and Hayes model, determining that translating consisted of two sub-processes, identified as “text generation” and “transcription.” Text generation consists of converting ideas into language representations within memory, while transcription is the process of transforming the language held in memory into written output (Berninger, 1999).

Reviewing. Reviewing is the process of examining what has been written and making identified changes (Flower & Hayes, 1981).

While students with DWE experience difficulties with all three writing processes, the skills associated with “translating” represent the most significant problems incurred by students with DWE (De La Paz, 1999; Graham, Harris, MacArthur, & Schwartz, 1991). Berninger (1999) states that they often do not have the handwriting and spelling abilities needed to convert ideas held in the form of oral language into printed text. Berninger also asserts that memory plays a significant role in translating. The sub-process of transcription requires access to information held in short-term memory or long-term memory. The sub process of text generation requires students to coordinate multiple stores and multiple processes in their working memory. During the writing process of translating, the sub-processes of transcription and text generation compete with each other for the student’s limited resources. The degree to which the student is able to complete transcription skills affects the extent to which resources are available for text generation and other high-level cognitive processes of composing (Berninger et al., 1992; McCutchen,1995, 1996).

Intervention Strategies

Interventions used to address the needs of students with DWE can be categorized as being remedial or compensatory. Remediation is an approach that involves interventions that attempt to correct the concern demonstrated by the student. Common remedial approaches used with students with DWE include additional instructional time and the use of alternative instructional approaches (Edyburn, 2002). A compensatory approach involves circumventing the function the student cannot perform (Edyburn, 2002; Parette & Peterson-Karlan, 2007). Examples of compensatory approaches used with students with DWE include modified assignments, the use of scribes, and the use of assistive technology (AT).

AT for Writing

A number of AT tools have been described in the literature as a means for addressing the functional area of writing for students who struggle with the skill, including students with DWE (Berninger & Amtmann, 2003; MacArthur, 1999; MacArthur, 2000; MacArthur, 2009). The tools primarily consist of computer software that address one or more of the processes or sub-processes that comprise the task of written composition. The primary applications that are commonly used to address the writing needs of students with disabilities include graphic organizers, word processors, and software that enables word prediction, speech recognition, and text-to-speech (MacArthur, Ferretti, Okolo, & Cavalier, 2001).

Background of the Research Problem

A significant amount of evidence exists related to the use of remediation strategies with students who have DWE. Instructional interventions including graphic organizers, strategic and procedural support for writing and explicit instruction are all recognized in the literature as effective interventions in the classroom for students who have DWE (Smith & Okolo, 2010). The use of assistive technology as a compensatory strategy, however, has not been as well researched. The literature provides limited support for the use of these tools to aid writing (Zhang, 2000). This is particularly true for the use of word prediction and text-to-speech software, and their relevance to students who have DWE (MacArthur et al., 2001).

Word prediction software is intended to assist persons who have difficulty with writing, or persons with physical disabilities with limited ability to type (MacArthur, 1999). This software aids these two groups by predicting a word list based on the initial letters entered by the typist. In general, published research findings have supported the use of word prediction as a tool to aid students with DWE particularly as a tool to compensate for poor spelling (Mirenda, Turoldo & McAvoy, 2006). Unfortunately, the findings that exist are limited in number, and many of them are dated (Siliò & Barbetta, 2010). Further complications include the fact that, like other forms of computer technology, assistive technology applications have advanced significantly in recent years. Current versions of word prediction software have improved compared to earlier versions. Current versions offer predictions based on phonetic spellings, linguistic prediction of next words using linguistic and

grammatical rules and automatic grammar and punctuation assistance (Mirenda, Turoldo & McAvoy, 2006; Evmenova, Graff, Jerome, & Behrmann, 2010).

Text-to-speech (TTS) software converts standard text into audible speech (Lange, McPhillips, Mulhern, & Wiley, 2006). This software is typically identified as a tool that aids students with DWE during both translating and reviewing. Like word prediction, much of the evidence supporting the use of TTS is limited and dated (Siliò & Barbetta, 2010). An emerging trend in the use of word prediction and TTS is their use in combination. Two recent studies have analyzed the use of text-to-speech in conjunction with word prediction. Silio` and Barbetta (2010) used a multiple baseline design across subjects with Hispanic boys with specific learning disabilities to compare word processing, word prediction with word processing, text-to-speech with word processing and, word prediction and text-to-speech combined with word processing. Cullen, Richards & Franks (2008) used a multiple baseline design with a mixed group of students, identified as having problems with written expression, to compare handwritten samples to text-produced samples using text-to-speech software in combination with spellcheck and text-to-speech in combination with word prediction. While these studies support the use of word prediction in combination with text-to-speech, a review of the studies' design features indicate results that are limited when applied to students with DWE.

Purpose of the Study

The purpose of this study was to investigate the impact that the combination of both word prediction and text-to-speech software has on the writing process of "translating," demonstrated by students with DWE. This research hopes to contribute directly to the growing body of evidence regarding the use of this assistive technology by students with DWE.

Research Question

The research question of this study asked: Will students with Disorders of Written Expression (DWE) demonstrate improvement in the writing process of translating, when using the software applications of word prediction and text-to-speech in combination?

Definition of Terms

Key terms associated with this study are defined as they appear in the context of this paper. A few of the terms require additional attention.

Assistive technology. Assistive technology refers to tools that assist students with disabilities address educational problems they may be having (Blackhurst, 1997). Assistive technology can be viewed as a continuum of possibilities ranging from simple to complex. The best type of assistive technology is that which helps the student engage in the educational process. This view helps to illustrate that the best may be as simple as a pencil grip, or as complex as speech recognition software.

Translating. Translating is the process of converting ideas into visible language (Flower & Hayes, 1981). Key elements of translating are converting ideas into actual words (text generation) and converting the words held in memory into words on a page. This study will assess translating by measuring total number of words written, spelling accuracy, and syntactic maturity by measuring mean T-unit length (MTUL). A T-unit (TU) is described as a main clause and all of its subordinating clauses (Hunt, 1965). TU is a shortened name for what Hunt (1965) first called "minimal terminable units". He explained that TUs were minimal in length and could be terminated grammatically between a capital letter and a period. Quality of writing or grade level of writing will not be part of the assessment of translating.

Word Prediction. Word Prediction (WP) software functions by predicting a word list based on the initial letters entered by the typist (Peterson-Karlan & Parette, 2007). A student, who experiences difficulty with spelling, might want to type the word "human". They begin by typing the letter "h". Doing this causes a list of words to appear that begin with this letter. Adding a "u" would cause the list to change, the word list changes listing words that start with "hu" such as "hurt" or "human". The user then has the choice of selecting the word from the list by clicking on it with a mouse or typing the function key that is associated with the word in the list.

Text-to-speech. Text-to-speech (TTS) software translates letters and words typed by the user into synthetic speech (MacArthur, 1999). This software allows the student to hear words "spoken" by the computer as they type them. In this case, the students can use text-to-speech to speak the words generated in the word prediction list as well as prior to selecting it.

Literature Review

DWE and the Writing Process

Students with DWE can experience a number of difficulties when completing writing tasks. One way to examine these difficulties is to describe them as they relate to an identified model or existing theory. A commonly used theory that examines the writing process is Flower and Hayes' (1981) Cognitive Process Theory of Writing. It is an accepted standard that describes the process of writing by viewing it in terms of the cognitive processes used to compose. This theory organizes the process of writing into three distinct reoccurring cognitive processes: planning, translating and reviewing (Flower & Hayes, 1981).

Planning. Planning is defined as the formation of an internal representation of the knowledge that will be used for writing. It is composed of three sub-processes including idea generation, idea organization and setting goals (Flower & Hayes, 1981).

Idea Generating. Generating ideas involves the process of retrieving information stored in memory in response to a writing prompt. The information that is accessed may be well developed and organized or may be fragmented and unconnected.

Idea Organizing. The sub-process of idea organizing aids the writer in making meaning of generated ideas when the information in memory is not sufficient for the writing task. It allows the writer to take his/her ideas and place them in a useful structure. Organizing ideas includes idea grouping, concept formation and category identification (Flower & Hayes, 1981).

Goal Setting. Writing goals can be procedural or substantive and may occur concurrently. Procedural goals direct the writer in terms of the organization of a writing product or the specific steps that are to be followed. Substantive goals deal more with the content of the product and desired outcomes based on established criteria. Goals may be drawn directly from memory or developed during the writing process using the same processes that generate ideas (Flower & Hayes, 1981).

Students who have DWE experience a number of problems with planning and the sub-processes that comprise it. Frequently students with DWE exhibit an inability to sustain thinking and identify a purpose for their writing (Graham & Harris, 1997). Because they exhibit difficulty

with planning what to write, they seldom research new information and tend to limit themselves to information already in their memory when responding to prompts (Graham & Harris, 1997). Additionally, limitations in planning restrict their ability to consider the requirements of the reader, content requirements and overall organization of the writing product (Newcomer & Barenbaum, 1991; Raphael & Englebert, 1990; Thomas, Englert & Gregg,1987).

Translating. Translating is described as the process of converting ideas into visible language (Flower & Hayes, 1981). Berninger (1999) amended Flower and Hayes' model with the determination that translating consisted of two sub-processes that he identified as text generation and transcription. Text generation consists of translating ideas into language within memory while transcription is the process of converting the language held in memory into written output.

The skills associated with translating present significant problems for students with DWE (De La Paz, 1999; Graham, Harris, MacArthur & Schwartz 1991). The most easily observed of these problems are those associated with the process of transcription. The problems that students with DWE experience with transcription are primarily related to the difficulties they experience with handwriting and writing mechanics (Berninger, 1991). Writing mechanics refer to the skills of capitalization, punctuation and spelling (Newcomer & Barenbaum, 1991). Problems experienced with handwriting and writing mechanics are believed to have a broader impact than the easily observed misspellings and messy paper. Problems in this area can affect all aspects of the writing process. This is illustrated by a student who is experiencing significant difficulty with spelling during the completion of a writing task. The student's need to attend so intently to spelling interferes with his ability to engage in planning and text generation. A student who is struggling to spell a word may forget or lose track of what they were planning, interrupting the process of converting their ideas into words and distracting them from attending to the specifics of the writing prompt (Graham, 1990). An additional problem associated with poor handwriting and writing mechanics is the rate at which the student is able to produce content. Students with this limitation may not be able to generate content fast enough to keep up with their thoughts, which can then further interfere with the processes of planning and text generation. A third concern associated with transcription is that the students use a limited vocabulary because they avoid the

use of words they are unable to spell. A final concern associated with transcription is the mechanical production of text. The inability to write in an intelligible manner negatively affects the student's motivation and persistence with writing (Graham, 1990).

Reviewing. The third component of the writing process identified by Flower & Hayes (1981) is reviewing. Reviewing is the process of examining what has been written and making identified changes. Evaluating and revising are the two sub-processes associated with this process (Flower & Hayes, 1981). Evaluating includes assessing what has been written. The student may evaluate the mechanical aspects of writing, such as spelling, grammar, and punctuation or the organizational and content aspects of the product. Revising is the process of making changes identified through evaluation. Reviewing can occur as a conscious effort that is part of a systematic evaluation of their work, or spontaneously, during the writing process. During review, the student may revise what is written as well as unwritten thoughts (Flower & Hayes. 1981).

When engaged in the reviewing process, students with DWE tend to focus their efforts on making corrections related to writing mechanics. Spelling, capitalization and punctuation errors become their focus when reviewing a document. Graham and Harris (2003) indicated that more than 70 percent of the changes made by students with DWE are to correct mechanical errors. Even with these attempts to correct their errors, the students still produce written work that has significant numbers of spelling and punctuation errors (MacArthur, Haynes & DeLaPaz, 1996). Revising is also a concern for students with DWE. These students exhibit limitations in their ability to evaluate their writing based on its content, organization, clarity and detail and in making intended changes (Graham & Harris, 2003).

Overall, it is recognized that all three of the processes of writing provide challenges to students with DWE. A confounding factor is the fact that the problems described do not occur in isolation. Problems that a student experiences in one area of the writing process can negatively impact the others. As has been illustrated, the writing process is not a sequence of processes but instead should be viewed as a set of actions that are accessed by the writer as needed (Flower & Hayes, 1981). Flower and Hayes describe the writing process as a hierarchical system in which

processes are composed of sub-processes and one where a process can be called upon at any time and may be embedded within another process.

Assistive Technology

Assistive technology (AT) has been identified as a possible remedial approach to address the problems experienced by students with DWE (Parette, Wojckik & Peterson-Karlan, 2005). The most recent reauthorization of IDEA 2004 defines an AT device as:

> 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 a child with a disability. The term does not include a medical device that is surgically implanted, or the replacement of such device [Individuals with Disabilities Education Act, 2004, Part B, Section 602, (1)].

This definition is intentionally general to allow for the consideration of a broad spectrum of possibilities that could include simple items, such as foam pencil grips or more complex items, such as computer-based communication devices (Beard, Carpenter & Johnson, 2011). The definition also speaks to what can be called, or identified, as AT. There are two criteria that must be met for something to be considered an AT device. The person using it must have a disability, and the purpose of the AT is to increase or improve function. Function refers to the specific tasks or activities that the student is required to complete or those activities that he wants to achieve. Incorporating this view of AT's purpose establishes the expectation that it should be considered for all students with disabilities during the IEP process, and that there should be an understanding of the area of function that will be addressed by the AT. The overall goal associated with the implementation of any AT is to enable students with disabilities to be able to do something they weren't able to do previously without the assistance of the AT, or to do it more effectively (Peterson-Karlan, 2007).

Regulations that local education agencies are required to follow related to AT are detailed in IDEA 2004. Section 300.324 – Development, Review, and Revision of Individual Education Program (IEP) states that when developing a student's IEP, formal consideration must be given regarding whether AT devices or services are needed (Individuals with Disabilities Education Act,

2004). Reed (2004) describes “consideration” as a thoughtful process that requires a thorough understanding of the student’s needs and a good understanding of the student. The primary rule that must be adhered to when completing this step is that all students with disabilities should be considered for AT services and devices as part of the IEP process. The student’s ability level or type of disability should not be a factor when identifying those students who might benefit from AT devices and services. For example, students who exhibit mild functional limitations should be given the same level of consideration for AT as students with significant functional limitations (Reed, 2004).

AT to Support Writing

The literature identifies several AT software applications that support the writing of students with learning disabilities. Technologies described include graphic organizer, word processor, word prediction, spell checker, speech recognition, and text-to-speech software as the primary examples of computer-based tools used to support the writing of students with learning disabilities (MacArthur, 1998, 2009; Peterson-Karlan & Parette, 2007). The literature related to each of these applications follows.

Graphic Organizers. Graphic organizer software allows the writer to develop a visual diagram of their ideas that can later be converted into an outline. Graphic organizers are meant to meet the needs of students who are visually oriented by allowing them to see the overall structure of their writing project, as well as the relationship between ideas in a pictorial format (Sitko, Laine, & Sitko, 2005). Graphic organizers serve to reduce the cognitive load associated with idea generation, idea organization and goal setting. They address these areas by making text more accessible and providing an organizational framework that allows students to generate and rearrange text. They can also provide prompts in the form of procedural reminders, questions that prompt ideas or word banks relevant to the topic being addressed (Englert, Wu & Zhao, 2005).

There is limited evidence to support the use of graphic organizers by students with DWE. Englert, Wu & Zhao (2005) compared the use of a web-based graphic organizer with computer only and paper and pencil to complete written narratives with twelve students with learning disabilities. The graphic organizer provided the students with topic sentence boxes that

incorporated prompts to provide supporting details. The students also had access to prompts regarding content, strategies and key words. The results indicated that the students performed significantly better in the graphic organizer condition. It was also noted that writing organization was particularly improved when using the graphic organizer (Englert et al., 2005). Bahr, Nelson and Van Meter (1996) compared software that provided structured writing prompts with software that allowed the participants to create graphic scenes and then write about them. The study was conducted using 9 students with learning disabilities. The results indicated that the students who had less internal organizational ability benefited from structured writing prompts. Students who had stronger organizational skills wrote better with the graphic based features of the tool. Finally, Sturm and Rankin-Erickson (2002) compared the effects of hand-drawn and computer based graphic organization on eighth graders with learning disabilities. The results of the study indicated that the number of words, T-units and holistic writing scores for both the computer based graphic organizer and the hand drawn organizer improved, compared to baseline writing samples. The students also demonstrated a more positive attitude to the computer-based graphic organizer than the hand drawn and no organizer conditions.

Word Processors. Word processing is a powerful technology tool that supports the writing processes of translating and reviewing. Word processing aids the process of translating by compensating for the handwriting and writing mechanics difficulties experienced by students with DWE (Berninger & Amtmann, 2003). Word processing supports reviewing through the use of the spellcheck features associated with it. Spell checkers assist by identifying misspelled words and by suggesting correct spellings (MacArthur, 1999). Peterson-Karlan and Parette (2007) suggested that word processors could be used to improve translating accuracy and length, and should be accompanied by the provision of keyboard training when used with students with DWE. A number of studies have incorporated word processing as a potential support for students with DWE. MacArthur, Graham, Schwartz and Schafer (1995) implemented a model of writing instruction with 113 students with DWE that integrated word processing, strategy instruction and a process approach. The results indicated that the students using the model program performed better in terms of the quality of their writing than students with DWE in a control group. The

authors also indicated that the benefits of using a word processor are dependent on how effectively the students have been trained to use its features. In an investigation of the effects of word processing on the text entry speed of students with learning disorders, Lewis, Graves, Ashton and Kieley (1998) compared word processing alone to word processing with four separate text entry strategies, that included keyboard instruction, an alternative keyboard, word prediction and word prediction combined with text-to-speech output. The authors found that handwriting remained faster compared to all the variations of word processing. The study also reported a decrease in spelling errors by the students with all the variations. Writing quality with word processing alone did not improve compared to handwriting, but did improve when word processing was combined with word prediction with and without speech. Zhang (2000) completed a year-long study to determine the effects of word processing on students' writing performances. The study involved five, fifth grade students diagnosed with learning disorders. The five students created 33 stories, and demonstrated an overall improvement in their writing. One student was identified as having made significant improvement, completing a writing piece that was 350 words in length that contained few spelling errors and incorporated compound sentences. Hetzroni and Shrieber (2004) investigated the effects of word processing on the written outcomes of three junior high students with learning disabilities. The study indicated that using a word processor to complete academic assignments resulted in fewer spelling mistakes, fewer reading errors and improved organization and structure.

Speech Recognition. Another software tool that can aid with the process of transcription is speech recognition software that converts spoken language into typed text (Parette, Wojcik, Perterson-Karlan & Hourcade, 2005). To effectively use this software, a user must first create a user profile by training the software to recognize their voice and how they speak. The immediate benefit associated with this technology is that it eliminates the need to type or write to compose written work. Unfortunately, the software has a number of limitations that must be considered. The first consideration is the accuracy of the software. Accuracy in this case refers to how accurately the software interprets what the user is saying. While recent versions are highly accurate, the accuracy achieved by different users can vary significantly (Shi & Zhou, 2011). A

second consideration is the need for the user to learn specific editing strategies. Editing in this case includes reviewing the document to ensure that the proper words have been entered. Editing is necessary due to the fact that speech recognition software does not make spelling errors. The inaccuracies associated with the use of speech recognition are in the form of incorrect interpretations of what has been said by the user (Quinlan, 2004). The person using speech recognition may say the word “cat”, but the software interprets their pronunciation as the word “hat”. A feature that is offered to assist with error identification is a playback feature that allows the user to listen to a digital recording of their dictation, and compare it to the text that has been created. Once errors are identified, it is preferable to correct them using editing commands that are issued by speaking. Editing in this manner is necessary to improve the accuracy of the software. A final consideration related to the use of this software is the necessity of an environment that has limited background noise and does not disturb others (MacArthur, 1999).

The literature available on the use of speech recognition, as a tool for students with DWE, is very limited. Since 2000, only two articles have directly assessed the effects of speech recognition on the writing of students with DWE. Several articles were written prior to this date, but the technology used in those studies was limited in its accuracy and was based on discrete speech versus continuous speech, which is the current standard (MacArthur, 1999). The little information that has been published provides support for the use of speech recognition with students who have DWE (Quinlan, 2004; Roberts & Stodden, 2005). Quinlan (2004) compared the effects of speech recognition software on children who were fluent and less fluent writers. Measures of fluency included total number of words written and t-unit length. The results indicated that the narratives composed by the less fluent writers had significantly more words compared to their handwritten narratives. The quality of the less fluent writers’ narratives did not demonstrate significant improvement. The author did note that a contributing factor to decreased quality was error correction. Students, who made more corrections using the speech recognition editing, produced lower quality narratives (Quinlan, 2004). Roberts and Stodden (2005) investigated the use of speech recognition with 15 adults participating in postsecondary education who had learning disabilities. The participants in the study were provided with initial training and

ongoing support in the use of software. The data that was collected was primarily qualitative in nature, and revealed that the use of the software and improvement in writing was contingent upon perceived need. Factors that influenced the use of software included time, ease of skill acquisition, and personal issues.

Text-to Speech. Text-to-speech (TTS) software translates letters and words typed by the user into synthetic speech (MacArthur, 1999). This software is identified as a tool that aids students with DWE during both transcription and reviewing. During transcription, the student can receive speech feedback as they type. Used this way, the writer can receive speech feedback as each letter, word or sentence is typed (Parette et al., 2005). During the process of reviewing, students are able to listen to what they have written using TTS. This process can result in the student recognizing incomplete or awkward sentences, misspelled words or errors of meaning. TTS can also be a feature that is embedded into word prediction software. TTS, in this instance, can be used to speak the list of words generated in the prediction list, or to provide feedback to the student by speaking a word as it is selected from the prediction list.

There is limited evidence describing the effects of TTS on the writing performance of students with DWE. An early study completed by Borgh and Dickson (1992) assessed the effects of TTS on the writing of elementary school students who did not have disabilities. The overall findings indicated that the group improved in the amount of editing it completed, and demonstrated more motivation to write when using TTS. Raskind & Higgins (1995) examined the effects of TTS on the proofreading of postsecondary students with learning disabilities. The study compared TTS, having text read aloud by another person and no assistance as methods of proofreading writing samples generated by the participants. The results of the study indicated that the students were able to detect a significantly, higher percentage of total errors using TTS. Additionally, the students identified a significantly higher percentage of capitalization, spelling usage, and typographical errors when using TTS. Having the text read aloud by another person was the most effective method for finding grammar errors. Other studies that have examined the effects of TTS on the writing of students with disabilities have looked at the combined effects of TTS with word prediction. These studies indicate that TTS and word prediction are more effective

at meeting the writing needs of students with learning disorders when they are used together, compared to their use in isolation (MacArthur, 1998, 1999; Lewis, Graves, Ashton, & Kieley, 1998; Cullen, et al., 2008). The studies, which used TTS in conjunction with word prediction, will be described in the word prediction section of the literature review.

Word Prediction. Word prediction software is intended to assist persons who have difficulty with spelling, or for persons who have physical disabilities that limit their ability to type (MacArthur, 1999). Word prediction tends to be a catchall term that encompasses two distinct functions. The first feature is word completion. Word completion functions by producing a word list based on the initial letters entered by the typist. A student, who experiences difficulty with spelling, might want to type the word “human”. They begin by typing the letter “h”. Doing this causes a list of words to appear that begin with this letter. Adding a “u” would cause the list to change, listing words that start with “hu” such as “hurt” or “human”. The user then has the choice of selecting a word from the list by clicking on it with a mouse or typing the function key that is associated with the word in the list. The second feature is termed word prediction. Word prediction works in conjunction with word completion. After a word is selected from the word completion list, word prediction functions by attempting to predict the next word in the sentence before any letters of that word have been typed (Anson et al., 2006). In the previous example, the user selected the word human from the word completion list. The word prediction or next word feature would then generate a new list of words before a letter is typed. In the example the word list might include the words “being”, “body” and “rights”. The list would begin to change as soon as letters are typed returning to word completion mode. The word lists that are generated by the software are developed using a combination of spelling and grammatical rules, and recently typed words (MacArthur, 1999). In most cases, products advertised as being word prediction programs actually have word completion as their primary feature and may or may not have word prediction as a feature.

Most recent studies investigating the effects of word prediction on persons with learning disorders, have occurred during two time frames. The first group occurred between 1998 and 2003 (Handley-More, Billingsley & Coggins, 2003; Deitz; Lewis, et al., 1998; MacArthur, 1998, 1999) and the second group from 2006 to 2010 (Cullen et al., 2006; Evmenova, Graff, Jerome &

Behrmann, 2010; Silio & Barbetta, 2010). The earlier group of studies incorporated word prediction software that did not have a number of features that are present in more recent versions. The most notable of these features is the availability of phonetic spelling.

MacArthur is recognized as a pioneer in the use of word prediction and other computer-based technology to address the writing needs of students with disabilities. In his initial word prediction study, he examined the effects of word prediction and speech TTS on the writing of 9 and 10 year-olds with learning disabilities. In the study the assistive technology software was used to aid the students in writing dialogue journals with their teacher. The results of the study indicated that four of five subjects demonstrated improvement in legibility and correctly spelled words. The study did not find any change in the length of written entries (MacArthur, 1998). In a later study he reported the findings of two studies included in the same article (MacArthur, 1999). The study included three students with significant spelling problems who wrote daily journals alternating between the use of handwriting, word processing and word prediction with text-to-speech. The results indicated that only one of the students spelled more words consistently correct using the word prediction text-to-speech combination.

MacArthur (1999) followed that study with a replication of the first, using the same three students and conditions, but incorporated a more demanding writing task. The results of the study revealed that two of the students improved in legibly and spelling. The author noted that a limitation of the word prediction software at the time was the need to know the correct first letter of a word for it to be useful (MacArthur, 1999). Hadley-More et al. (2003) investigated whether word processing and word processing with word prediction were effective in improving the writing of students with learning disorders who also had identified handwriting problems. A single-subject, alternating treatment design was replicated with three children in grades 4 and 5. The students wrote stories by hand during baseline, then in intervention alternated between using handwriting, word processing and word processing with word prediction. The study used the word prediction program Co:Writer version 1.1. The results of the study indicated that two of the students' legibility and spelling improved when using the word processor or word processor with word

prediction. Rate of writing was determined to be faster when using handwriting but was not clearly preferable to word processing (Handley-More et al., 2003).

The second group of word prediction studies all incorporated word prediction software that featured phonetic spelling and other improved features compared to the previous group of studies. An additional feature of each of these studies is the use of TTS either in combination with the word prediction or alone. Cullen et al. (2008) examined the effects of a word processor with TTS capabilities and spellchecker used alone and in combination with word prediction software. Using a modified multiple-baseline design, the software was used with seven fifth graders diagnosed with learning disorders (5) or mental retardation (2) to complete daily writing exercises. Baseline measures were determined using a daily writing sample that was completed using handwriting. These samples were converted to word-processed text to avoid the possibility of bias. Following baseline measures, two intervention phases lasting three weeks each were used. The first intervention utilized word processing, TTS and spellchecking. The second intervention added word prediction to the other AT programs. The dependent variables that were assessed included mean number of words, mean number of misspellings, accuracy percentage and writing rubric score. While individual scores varied, overall average scores of the group improved for mean number of words, mean number of misspellings and accuracy. It was also determined that the average scores obtained using the combination of word processor with TTS and word prediction were better than those obtained without the use of word prediction (Cullen et al. 2008).

Evmenova et al. (2010) investigated three different word prediction programs to determine if there were differences in length, spelling accuracy, or rate of journal writing across the different word prediction programs. Additionally, the study sought to identify the students' reactions to the different word prediction programs. Subjects for the study included six grade-school-aged students with severe writing and/or spelling problems. Utilizing a changing conditions single-subject design, the research was conducted during a 4-week technology-based summer writing camp. The three word prediction programs that were compared included Co:Writer, WordQ and WriteAssist. It is noted that all three of these programs include TTS feedback as an option. The study proceeded by establishing a baseline level of performance and then progressed to the

treatment condition. During treatment the students were randomly assigned to one of the word prediction programs and then used it for a week. Following this they moved to different word prediction program the next week and another the final week. The results indicated that overall, the group demonstrated improvement, especially in spelling accuracy. The interviews conducted with the students following the completion of the study, indicated that they enjoyed using the word prediction programs and found them beneficial. When asked to compare the three programs, four of the six students indicated that they preferred WordQ (Evmenova et al., 2010).

Silio` & Barbetta (2010) conducted the most recent study involving word prediction and TTS. Their study incorporated a multiple-baseline design across subjects to investigate the effects of word prediction and TTS alone and in combination on the composition writing of fifth grade Hispanic students with learning disorders. To implement the study, the subjects were randomly divided into two groups. Following the completion of baseline measures; the students were provided with individual training prior to beginning intervention phase 1, and again before initiating intervention phase 2. During intervention, Group A used word prediction, and then added TTS in the second intervention. Group B began using TTS, and then added word prediction in the second intervention. The results indicated that word prediction used either alone, or in combination with TTS, had positive effects on the writing of the participants and that TTS used alone resulted in little or no improvement (Silio` & Barbetta, 2010).

In summary, it is recognized that students with DWE can experience a number of problems engaging in the writing process. One mechanism described in the literature that can be used to address these problems, is the use of AT. Of the variety of AT available to address the problems experienced by students with DWE, word processing combined with word prediction and TTS have initial evidence to support their use with students with learning disabilities.

Methods

Participants

Participants for this study were identified with assistance from a special education association that provides special education and related services to parochial schools in a large Midwestern city. Resource Room teachers employed by the association were provided with inclusion criteria for the study, and were asked to provide potential participants' parents with recruitment letters. To be eligible for inclusion in the study, participants had to be an elementary or junior high school student enrolled in third through eighth grades, with a diagnosis of Disability of Written Expression (DWE). Students who met the inclusion criteria, and who may have had related diagnoses, as well, were included in the study. Students who met the inclusion criteria, but spoke English as a second language, were excluded from the study. It was felt that students who did not speak English as their primary language may present with additional problems with writing that would not provide equal comparison to the other participants.

Once students who met the inclusion criteria were identified by the Resource Room teachers, they were provided with a recruitment packet that they were instructed to take home to give to their parents. It is noted that the Resource Room teachers did not share with the primary researcher the names of the students who met the inclusion criteria.

The recruitment packet included a Recruitment Letter, a Registration Form, an Informed Consent Form, an Assent Form, and a self-addressed stamped envelope. The Recruitment Letter (see Appendix A) outlined the nature of the research, explained what the students would be asked to do, and described the potential risks and benefits of the research study. The letter also stated that participants would receive a ten-dollar gift card for attending the first session, and a copy of the WordQ software used in the study if they completed all three sessions. Contact information for the primary researcher and the Resource Room teacher was included in the letter to allow parents the opportunity to ask questions related to the research study. Parents who indicated a willingness to allow their child to participate were instructed to mail their completed Registration Form and Informed Consent Form (see Appendix B) to the primary researcher in the provided, self-addressed stamped envelope. Once the primary researcher received the

Registration Form, he contacted the family to schedule a time for them to participate in the research.

Eleven students initially indicated their willingness to participate in the study. When students were scheduled for a research session, they were assigned a participant number. During the study, one of the participants who was scheduled to participate in research sessions did not arrive to participate in the first session at the agreed upon time and date. It was later learned that this occurred due to a communication error with the participant's parents. Because of this, the student was excluded from the study, leaving ten students who participated in the study. The participants' demographic information is presented in Table 1. The student who did not participate in the study was assigned the participant number seven, which explains the gap in the numbering presented in Table 1.

Table 1

Participant Demographic Information

Participant Coded Identity	Gender	Grade Level	Age
1	Male	8	14
2	Male	7	12
3	Male	7	12
4	Female	3	8
5	Male	3	8
6	Female	5	10
*			
8	Female	5	10
9	Male	7	12
10	Male	4	11
11	Female	8	13

*Note: Participant number 7 did not complete the study

Setting

The study was conducted in the assistive technology computer lab of an occupational therapy educational program. The lab contained six computers that are placed on computer tables located along two walls (See Figure 1). All of the computers used for the study were the same type of desktop personal computer with identical components and features. The computers had standard QWERTY keyboards and two button mice. Visual information was displayed on 15-inch LCD displays. Standard, over-the-ear headphones were used for sound output. Adjustable office chairs with arms were located at each of the computer stations. The room was equipped with a large, wall-mounted, flat screen television that was used to show training videos. During the study, the participants used the computers labeled Computer 2, Computer 3 and Computer 6 in Figure 1. This arrangement allowed for adequate space between the participants for the purpose of decreasing distractions. To further prevent distraction associated with the use of text-to-speech, the participants wore headphones during the posttest writing sessions.

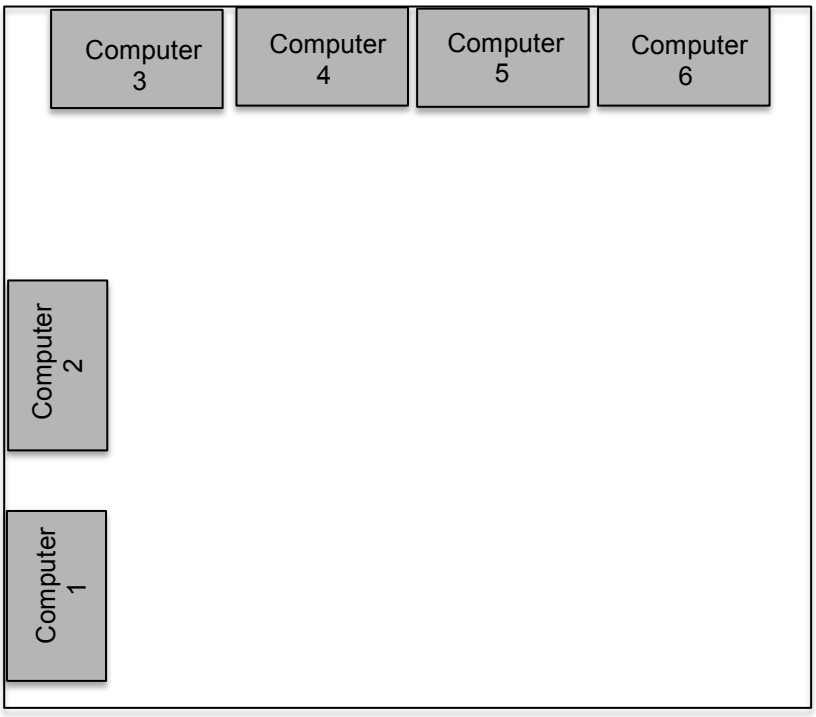

Figure 1. Diagram of the assistive technology computer lab and computer arrangement

Materials

The assistive technology software that was used during this study was WordQ™ which is a software program designed to assist individuals to engage in writing and reading activities. The primary features of WordQ are word completion/prediction (Words), and text-to-speech (Speech and Reading). Once the program is opened, it appears as a small 4-button toolbar that can be positioned anywhere on the computer screen. A screen shot of the WordQ toolbar is displayed below in Figure 2.

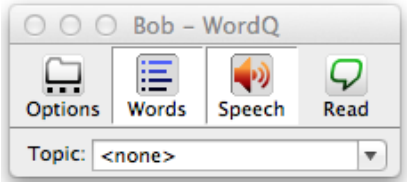

Figure 2. A screen shot of the WordQ toolbar.

Each of the buttons on the WordQ toolbar represents a function of the software. To activate a function, the user clicks on the button with the mouse, or presses a designated Function-key. When a button has a light background, that function is activated. In Figure 2, the *Words* and *Speech* features are active and *Reading* is deactivate. The *Words* button activates the word completion/prediction feature. The *Speech* button activates text-to-speech that reads words and sentences as they are read and also reads words in the prediction list when the mouse cursor is held over them. The *Read* button is activated when the user wishes to review a section of text. The text to be read is selected and then read to the user one sentence at a time. The fourth button is the *Options* button, and is used to adjust the various features of the software. Each of the program's features can be used individually, or in conjunction with the others.

An individual WordQ user file was created for each participant prior to participating in the study. Creating individual user files allowed the software to adapt to the participants by learning which words were used most frequently throughout the writing sessions. Changes to the participants' user files were saved at the end of each session.

All of the participants used the same Options settings for the study. Figure 3 illustrates the various choices available via the Options button. Prediction, Speech Feedback and Hot Keys represent the three main areas of customization available.

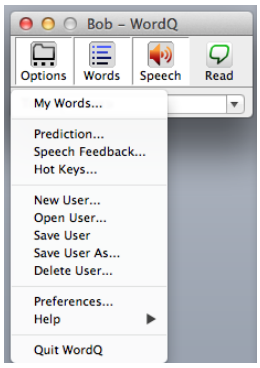

Figure 3. WordQ Options button menu items

The menu item *Prediction* features three areas of customization including *Word List, Prediction* and *Selection* (See Figure 4). The *Word List* options available for prediction are shown in Figure 4. All of the participants' files for number of words were set as they are displayed in Figure 4, including: *Displaying five words in the prediction list, Display synonyms, Display usage examples, Order words in most likely order, Use a vertical list layout* and *Follow text cursor*.

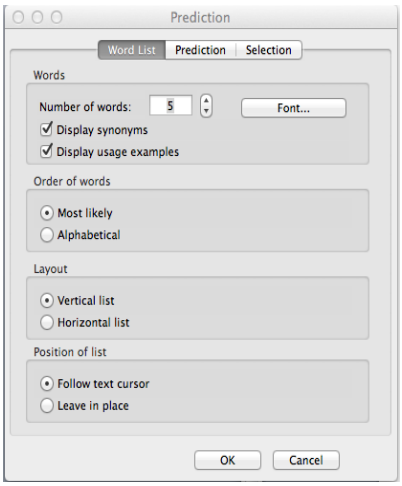

Figure 4. WordQ Word List options

Figure 5 displays the options available for *Prediction*. The default settings for *Word prediction* were used, which included the use of all options, except *Adapt predictions based on how I combine words*. Default settings for *Following a word prediction* were also used for all participants, which included using the features: *Add spaces and adjust punctuation* and *Capitalize the first word of the next sentence*.

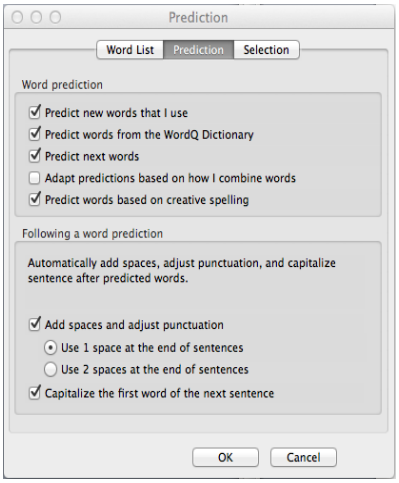

Figure 5. WordQ Prediction options

Figure 6 displays the options available for selecting words from the prediction list. Both *Keyboard* and *Mouse Selection* options were used for all participants, with *Use of the number line* set as the keyboard preference for all participants.

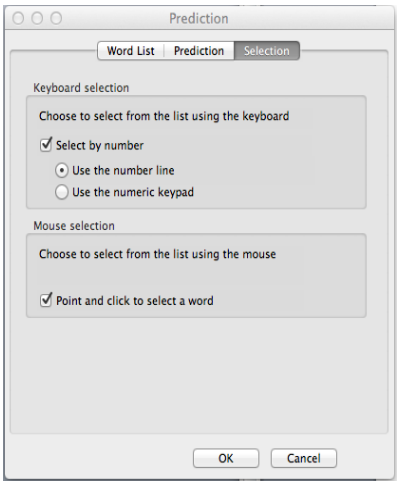

Figure 6. WordQ Selection options

Wordpad, a basic word processing program that is part of the Microsoft Windows™ operating system was used for all writing sessions. It was selected because of its ease of use and simple appearance. The software was set up with the spell check feature turned off and the editing toolbar not visible. Figure 7 is an image of WordPad, and the prediction window from WordQ being displayed.

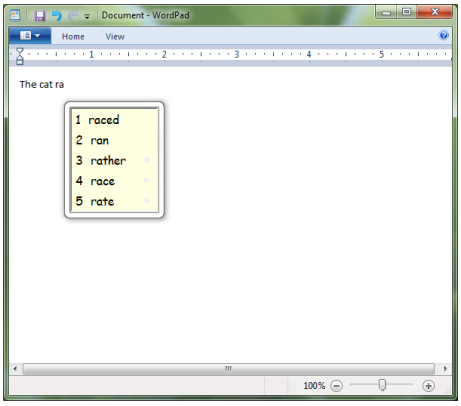

Figure 7. Screen shot of WordQ word prediction feature being used with WordPad™

Research Design

A modified version of the multiple baseline case series design was used as a means of establishing a consistent and uniform implementation of the intervention, and encouraged participation by subjects that met the inclusion criteria. Multiple baseline designs typically use the collection of baseline data concurrently across multiple data points. Once stability is achieved for all subjects, the intervention is implemented with the first subject. Subsequent interventions are introduced with the remaining subjects in a staggered fashion to increase the reliability that any changes observed are associated with the intervention. A key requirement of the multiple baseline design is the availability of time to establish baseline stability across subjects, and then stability of each subject, following the introduction of the intervention (Portney & Watkins, 2009).

In planning this research, a number of possibilities were considered related to the design. A true multiple baseline design was desired, but implementing it presented a number of problems. To conduct a true multiple baseline design would require access to students on a daily basis for

an extended period of time. The primary concern was an inability to obtain daily access to a group of students who met the inclusion criteria. Approaching public schools was not considered as a possibility, because of policies that do not allow non-employees access to students to conduct research.

Private schools were considered as a possible option to access students, but they typically only have small numbers of students who would meet the stated inclusion criteria. A second concern related to completing research in a private school is the inconvenience it causes to the school and teacher.

An alternate strategy that was considered was the use of classroom teachers or Resource Room teachers at the schools to conduct the research. This alternative also presented concerns, based on the inconvenience it would place on the teacher and the classroom and the potential for inconsistent implementation from across teachers. A final consideration related to the design of the study was a desire to obtain as large a sample as possible to allow for the completion of statistical analysis.

Due to the barriers listed above, a research design was conceived that differed in a number of ways from a true multiple baseline case series design. To address the primary concern of not being able to access students in their classrooms for an extended period of time, and to maintain consistency during implementation, it was determined that the data would be collected on three separate occasions over a three-week period. Additionally, multiple data points would be taken during each of the sessions. This design offered the best opportunity for obtaining the largest number of participants who would complete all three sessions of the study.

Collecting data at multiple points was identified as a key design feature. Multiple baseline case series designs include multiple measurements collected during baseline and intervention phases over multiple days. In the design that was implemented, two measurements were taken to establish baseline in the first session, and single baseline measurements were taken at the beginning of the second and third sessions. Similarly, a single intervention measurement was taken during the first phase and two intervention measurements were taken in the second and third phases (see Table 2). This design alternative allowed for multiple points of data to be taken

over the course of the research. It must be acknowledged that these modifications to the true multiple baseline case series design increased the possibility that the data taken at those points would not be a true reflection of each participant's performance. Additionally, because the collection of data occurred over three separate phases, there was a threat to internal validity, due to the possible effects of history and maturation of the participants.

Another difference in this study from typical multiple case series designs, was that the participants used the intervention at least once during each of the sessions. In multiple baseline case series designs, once baseline is established, one of the participants is moved into the intervention phase, while the others remain in the baseline phase. After the participant in the intervention phase demonstrates stability, he returns to baseline phase while another participant moves into the intervention phase. Because of the desire to obtain as many participants as possible, it was determined that this method of introducing the intervention would likely limit the number of participants who would be willing to participate in the study. It was recognized, however, that by not moving only one participant at a time into the intervention, it decreased the possibility that the changes observed during intervention would actually be due to the intervention, and not due to another factor.

To maximize the potential for obtaining the most participants as possible, a non-concurrent design was implemented. The study included three research sessions that occurred over a period of three months.

Structure of Sessions

The structure of each of the sessions was given significant consideration in recognition of the objective to investigate the impact that the combination of word prediction and text-to-speech software had on the writing process of translating of students with DWE. Table 2 provides an outline of the activities that occurred during each of the sessions.

Table 2

Structure of Sessions

Session 1	Session 2	Session 3
Pretest 1A	Pretest 2	Pretest 3
Pretest 1B	Video Training 2	Posttest 3A
Video Training 1	Posttest 2A	Functional Training 3
Posttest 1	Functional Training 2	Posttest 3B
	Posttest 2B	

Session 1 consisted of two pretests, identified as Pretest 1A and Pretest 1B, training in the use of WordQ, using video identified as Video Training 1; and a posttest, identified as Posttest 1. Two pretests were used due to a concern that the participants' initial writing performances may not reflect their true abilities. This concern was based on a number of factors, including the participants' ages, their unfamiliarity with the setting, the nature of the activity, and the possibility of nervousness. Any of these concerns could contribute to the participants performing below their actual ability level. An accurate measure for the initial pretest was necessary, because it would serve as the primary point of comparison for the posttests in Sessions 2 and 3.

Session 2 consisted of a pretest, two posttests identified as Posttest 2A and Posttest 2B, and two different types of training. The order of the activities were: pretest, video training, posttest, functional training and posttest. Video Training 2 was completed in the same manner as it was in Session 1, and served to reinforce the concepts covered in Session 1. The second training was labeled Functional Training, and consisted of a practical application of WordQ. The purpose of designing the training in this manner was to give the participants an opportunity to use the WordQ software in an applied manner. The Functional Training was designed to be a game-like, fun exercise for the participants. It was also designed to require the participants to use both the word completion and text-to-speech features of the software.

Session 3 consisted of a pretest, two posttests and one Functional Training session. The order of the activities of this session were: pretest, posttest, training, and posttest. The primary difference in this session from the previous two sessions was that the first posttest was completed without video training preceding it. The intent was to be able to make a comparison to the posttests that had video training precede them. Functional Training was the only training used in this final session. The rationale for this was that the participants at this point would view the training videos as being redundant, and that the applied approach used with the functional training would result in greater active participation by the participants.

Procedures

Intervention and data collection occurred during three separate sessions that occurred on three consecutive Saturdays. For all sessions, the participants entered the technology lab and sat at their assigned location.

Pretests. Pretest sessions began with the primary researcher reading the writing session instructions from a script (see Appendix C). For each of the pretest writing activities, the participants were asked to respond, in writing, to a picture-based writing prompt. The prompts were obtained from a book entitled, *75 Picture Prompts for Young Writers* (Brown, 1993). The intent of using the pictures was to limit the amount of planning the participants would have to do. The pictures that were used in the study were selected based on their perceived appeal to both boys and girls of a variety of ages. An example of one of the picture prompts is presented in Figure 8. In order to appeal to the participants' personal interests, a choice of two different picture-based writing prompts were offered for each writing activity. The participants were instructed to select the one they wished to write about. After selecting a picture, the participants were prompted to "*Look at the picture you selected, and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you would like about this picture. Use your imagination*." Each pretest writing activity had two pictures that were assigned to it, so that all of the participants selected from the same pairs of pictures for all the sessions. The participants were provided 10 minutes to complete each of the writing sessions, and were informed by the primary researcher when there were 2 minutes remaining. If a participant did not

engage in writing for a period of one minute, verbal encouragement to continue writing was provided. The participants were not prompted to review their work, but they were allowed to do so, if they so chose.

Figure 8. A sample of a picture based writing prompt used in the study.

Posttests. Posttest sessions were conducted in the same manner as the pretests. The only exception was that the participants were informed that they were to use the WordQ software to assist them with creating their writing sample. Prior to writing, the participants were prompted to open WordPad™ and WordQ. Additionally, the participants were prompted to activate WordQ's Word and Speech features before writing began.

Training. Training the participants in the use of the WordQ software was completed during all three research sessions. Two types of training were provided during the sessions.

Video Training. Video Training was used in Sessions 1 and 2, and involved the use of a specific sequence of videos available on the WordQ web site. The videos provided information on how to properly use the basic features of the WordQ software and addressed topics that included: activating and deactivating functions, adjusting sound feedback, three ways to choose words, selecting homonyms and proofreading (see Appendix C). The participants watched the videos on a large, flat screen television that was located in the technology lab. After viewing a video, the

participants were asked to complete a short activity on their computers that incorporated the feature that was just demonstrated in the video. The primary researcher took time to verify that each of the participants completed the activities, and was available to answer questions and provide assistance, if needed.

Functional Training. Functional Training was used in Sessions 2 and 3. In Session 2, the Functional Training session required the participants to use the WordQ software to write sentences that consisted of words that are commonly misspelled by elementary school students. The primary researcher read the sentences to the participants while they used the WordQ software to aid them in writing the sentences. The primary researcher provided assistance and encouragement to the participants as they completed this task. Assistance involved suggesting alternative letters and verbal cues to look more closely at the word prediction lists that were generated by WordQ. In Session 3, the Functional Training began with a review of the primary features of WordQ. During the review, the participants were asked to explain how to use the various features of WordQ that were previously covered in the video training. Following this, they wrote sentences read to them by the researcher that contained commonly misspelled words. Finally, they were asked to use the WordQ software to review a two-sentence paragraph to attempt to find spelling and homonym errors.

Determining Dependent Measures

The process for selecting the dependent measures used for this study was guided by examples provided in the literature and a measure's perceived ability to contribute to answering the research question. The research question for this study asked if students with Disorders of Written Expression (DWE) would demonstrate improvement in the writing process of translating, when using the software applications of word prediction and text-to-speech in combination. To effectively answer the research question, the dependent measures needed to directly reflect the participant performance as it related to the writing process of translating. Areas of performance associated with translating that could be considered as dependent measures include legibility of handwriting, capitalization, punctuation, spelling, amount written, and use of unique vocabulary (Graham, 1990; Berninger, 1991; Newcomer & Barenbaum, 1991).

Legibility. Legibility was not selected as a dependent measure in the study. Legibility has been used as a dependent measure in word prediction and text-to-speech studies when handwritten writing samples were used to establish the baseline (MacArthur 1998, 1999; Handley-More et al., 2003; Cullen et al., 2006). For this study, it was determined that the most appropriate comparison would be word processing alone, compared to the use of word processing with word prediction and text-to-speech. It was reasoned that if the students had limited experience with keyboarding, this limitation would affect both conditions equally, so legibility was not used a dependent measure.

Capitalization and Punctuation. Capitalization and punctuation were not selected as dependent measures in this study. While capitalization and punctuation errors occur during translating, students with DWE typically correct them as part of the process of reviewing (Graham & Harris, 2003). Word prediction software can assist with punctuation by being set to automatically capitalize the next word after a period is used, but it does not offer suggestions related to the use of other punctuation. Word prediction software can offer capitalized proper nouns, if those words are a part of its dictionary. Text-to-speech may assist users with the use of commas, when it is used as a tool to assist with reviewing. When reviewing written work, users can listen to the text via text-to-speech software. Through listening, they may be able to hear that a sentence is a run-on, and requires the use of a comma. Text-to-speech does not directly contribute to the use of punctuation as a part of translating. Neither capitalization nor punctuation errors are included in previously published studies utilizing word prediction and text-to-speech.

Spelling Errors. Spelling errors were selected as a dependent measure in this study. Spelling errors are recognized as a significant problem for students with DWE that could potentially be addressed by word completion/prediction and text-to-speech. When students begin to spell a word, they can use the word list generated by the word completion feature to assist them to complete the word. Text-to-speech contributes to this process by allowing the student to hear a word on the word list spoken, before selecting it and by hearing it spoken after it has been selected. Spelling errors have been used as a dependent measure in all of the recently published

research involving word prediction and text-to-speech (Cullen et al., 2006; Evmenova et al., 2010; Handley-More et al., 2003; MacArthur, 1998, 1999; Silio & Barbetta, 2010).

Amount of Writing. Amount of writing, as measured by number of words written, was selected as a dependent measure in this study. The amount of writing produced by students with DWE is an identified area of concern that word prediction/completion has been theorized as being able to address. By addressing problems that students have with spelling and transcribing, it has been anticipated that word prediction/completion would also help them produce more text. This as been measured in pervious studies by counting the total number of words written and the number of words written per minute (Cullen et al., 2006; Evmenova et al., 2010; Handley-More et al., 2003; MacArthur, 1998, 1999; Silio & Barbetta, 2010).

Unique Words. Number of unique words was not selected as a dependent measure in this study. It has been theorized that word prediction and text-to-speech would increase the number of unique words a writer would use, because of the assistance the software provides with spelling (Williams, 2002). A study conducted by Williams (2002) is the only previous study that utilized this as a dependent measure. That study counted the number of words in writing samples that were used only once. Identifying the number of unique words appeared to be difficult to assess as a dependent measure. A concern was that it would be significantly influenced by the nature of the writing sample.

Maturity. Maturity, as measured by Mean T-unit length was selected as a dependent measure for this study. Silio and Barbetta (2010) completed the only previous word prediction and text-to-speech study that included a measure of writing maturity. In their study, they counted the number of T-units that were present. T-units, or minimal terminal units, were identified by Hunt (1965) and described as one main clause and all subordinating clauses. Mean T-unit length has been identified as an effective means of assessing syntactic maturity, or the ability to manipulate language (Xinhua, 2008). Hunt indicated that mean T-unit length was directly related to a student's age.

Quality of Writing. Quality of writing was not selected as a dependent measure in the study. Two previous studies (Silio & Barbetta, 2010; Cullen et al., 2006) utilized rubrics that assessed

aspects of writing quality. Silio & Barbetta measured student writing samples utilizing a state assessment of writing rubric. Cullen et al. utilized a writing rubric that included measures of punctuation, capitalization and writing structure to measure school district mandated daily writing assignments.

Dependent Measures Definitions

The three different dependent measures were selected to assess the effects of word prediction and text-to-speech on the writing process of translating were Spelling Errors, Amount of Writing, and Maturity of Writing. The methods for measuring each of these are described below.

Spelling Errors was measured by the observation of Spelling Errors (SE). SE is a measure of the total number spelling errors within a writing sample. Besides incorrect spelling, words written in the incorrect tense or form were also counted as spelling errors. Homonyms and words spelled correctly but used inappropriately within the context were also counted as errors ("the baseball *prayer* caught the ball" vs "the baseball *player* caught the ball"). Mistakes in capitalization and punctuation were not considered spelling errors.

Amount of Writing was measured by the observation of Number of Words (NW). NW is a measure of the total number of words written during a writing session. It was measured by counting the total number of words that were written, whether they were spelled correctly or incorrectly. Proper nouns were counted as words, but numerals were not counted as words.

Maturity of Writing was measured by the observation of Mean T-unit Length (MTUL). MTUL is a measure of syntactic maturity. A T-unit (TU) is described as a main clause and all of its subordinating clauses (Hunt, 1965). The calculation of MTUL is done by dividing the total number of words by the number of T- Units. The following is an example of a writing sample with two T-units which are separated by a slash (/): "They are set up into heats from slowest to fastest / and so if you're starting out, you'll probably be in heat one." (Nippold et al., 2008). The first T-unit has a length of 10 words and the second T-unit has a length of 12 words for a MTUL of 11 words.

Evaluation

For the purposes of evaluation, a writing sample scoring protocol was developed (see Appendix D). The protocol included scoring guidelines for each of the dependent measures: NW,

SE and MTUL. After developing the protocol, the primary researcher scored three separate writing samples. To verify the scoring procedures, an educator with expertise in both writing and special education was instructed in the use of the protocol, and asked to score the writing samples. The researcher and educator were noted to have full agreement on their scoring, so the protocol was adopted.

Prior to completing any scoring, the primary researcher identified and trained a second rater. Training involved reviewing each of the items in the protocol and having the rater practice scoring writing sample examples.

Nine randomly generated numbers were used to label the participants' writing samples to randomize the scoring. Prior to each writing session three of the participants' numbers were placed next to their computer on a piece of paper. When the participants completed a writing sample, they typed one of the numbers on the top of the sample and then saved the sample using the number as the file name, on the computer they were using. At the end of the research sessions, the participants' files were transferred to a password protected flash drive and two copies of each sample were printed.

The first step in the scoring process was for the two raters to analyze and score the writing samples independently using the established scoring protocol. Following the completion of independent scoring, the two raters met to compare the scores they had determined for each of the writing samples. In the case of NW and SE, the comparisons served as an opportunity to assess the accuracy of the two raters. If differences were noted, the samples were reevaluated until consensus was reached on the actual counts for NW and SE. The raters also compared their scores for T-Units. Identifying numbers of T-Units was more difficult, and at times, subjective. The difficulty in scoring this dependent measure was due to the quality of writing demonstrated by the participants. Students with DWE frequently write using run-on sentences and with little or no punctuation. They also demonstrated frequent errors in spelling and grammar, which made determination of the number of T-Units more difficult. In cases where differences in number of T-Units occurred, the raters read through the samples together until agreement was reached.

Data Analysis

Prior to the completion of data analysis, consideration was given to the selection of pretest and posttest comparisons to be made from the large set of comparison possibilities. The research question for the study asked if students with Disorders of Written Expression (DWE) would demonstrate improvement in the writing process of translating, when using the software applications of word prediction and text-to-speech in combination. Determining improvement would require that the dependent measures be compared from posttest to pretest to determine whether significant differences existed between them. Figure 9 illustrates the possible comparisons of the data that could be made.

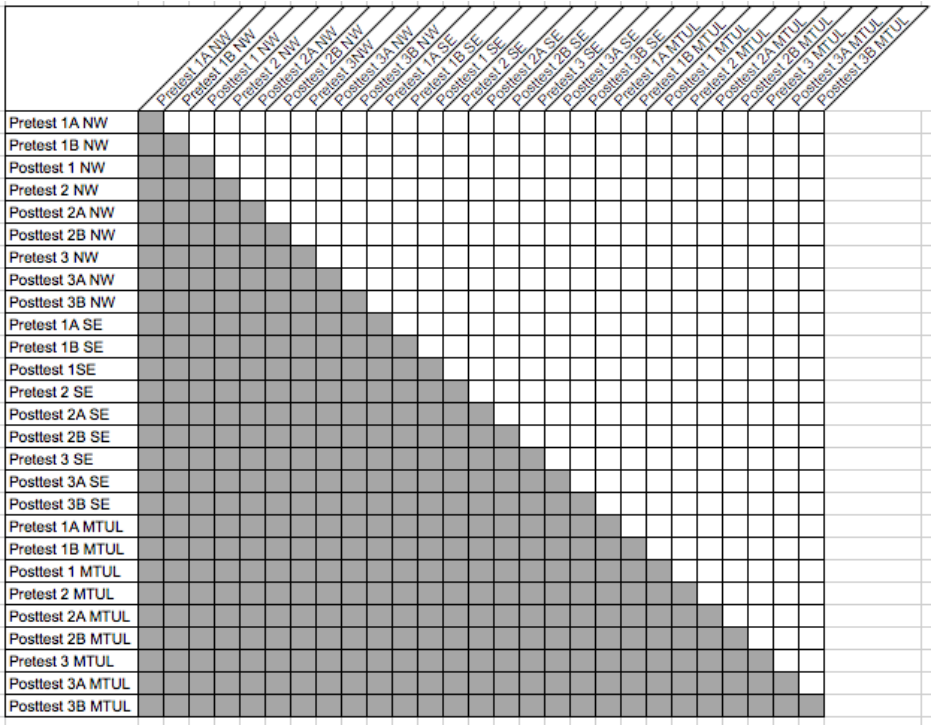

Figure 9. A table demonstrating the possible comparison of dependent measures that could be made.

The column headings and row headings list each of the dependent measures collected in the study. The table has eliminated comparisons of a dependent measure to itself. Additionally,

because the columns and rows each contain the same labels, there are two of each possible comparison in the table. The table has been shaded to reflect removal of comparisons of a measure to itself and all duplicate comparisons. Dark shading indicates that a comparison has been eliminated. Following the removal of these items, there remained 351 comparisons that could be made.

Returning to the research question as a guide, consideration included what should and should not be compared. The research question focused on whether or not improvement would be made in the writing process of translating. The question did not ask whether any correlations exist between any of the dependent measures. Based on this factor, it was acknowledged that comparisons would only be made between dependent measures of the same type, and that different dependent measures would not be compared to each other. By eliminating the possibility of comparisons between dependent measures of different types, the number of possible comparisons was reduced to 108, which is reflected by the unshaded cells in Figure 10.

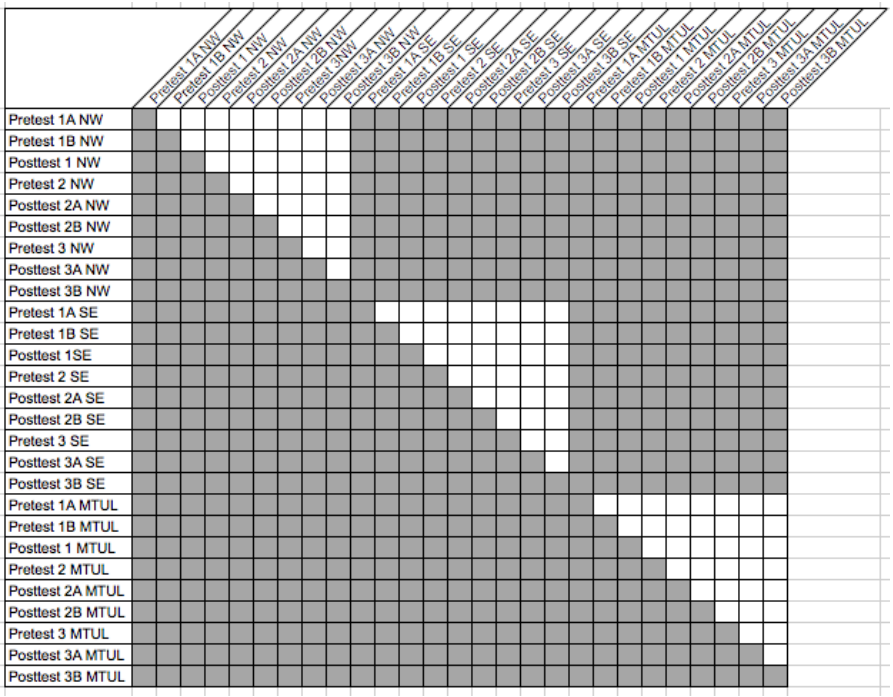

Figure 10. A table illustrating the possible comparison of dependent measures of the same type that could be made.

The remaining 108 possible comparisons are comprised of 36 possible comparisons for each of the three dependent measures. To determine if changes occurred in the dependent measure, comparisons will be made between pretest scores and posttest scores for each of the three dependent measures. Because the focus of the research is to determine if there is a difference between the pretests and posttests, it is unnecessary to make comparisons between the pretest scores of a dependent measure or between posttest scores. Eliminating these comparisons reduced the possible number of comparisons to 20 for each dependent measure, which is illustrated in Figure 11.

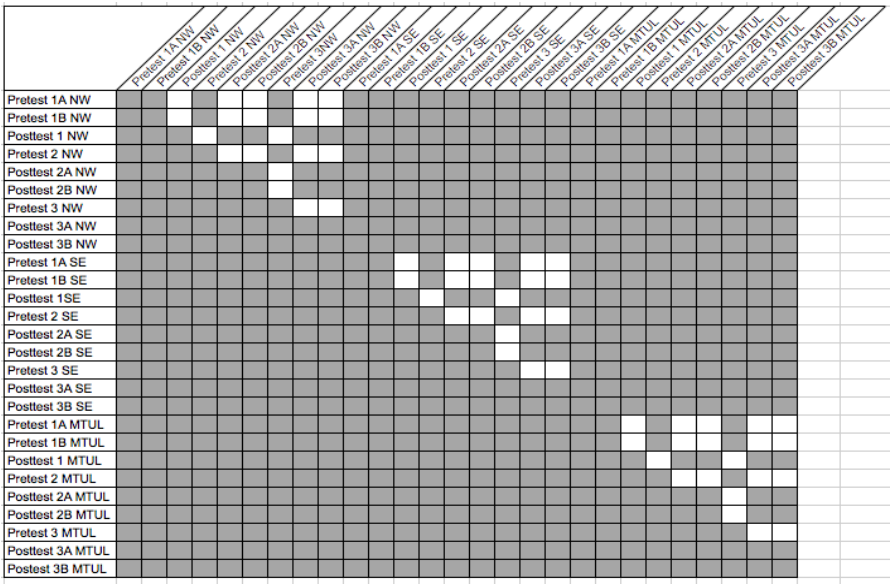

Figure 11. A table illustrating the 20 potential comparisons that could be made between pretest and posttest scores in each of the 3 dependent measures.

At this point, a determination was made regarding which of the remaining 60 possible comparisons would provide the most useful information related to the research question. The primary comparison that would be expected to reflect change or improvement is a comparison of the initial pretest to the final posttest. During Session 1, two pretests (Pretest 1A and Pretest 1B) were completed due to the concern that the initial pretest may not reflect the participants' actual abilities. Because of this, the scores from Pretest 1A were not used for comparisons. Scores from Pretest 1B were used as the point of initial measurement.

Table 3 lists the final set of measures that were selected for comparison. The two primary comparisons are the comparison of Pretest 1B to Posttest 3B and Pretest 1B to Posttest 2B. These two comparisons offer the best opportunity to observe if word prediction and text-to-speech had an effect on the dependent measures, based on the amount of time the participants had to learn to use the software. The other comparisons that were identified to add insight into the effects of the word prediction and text-to-speech software on writing were comparisons of dependent measure scores within each of the sessions. Comparisons of Pretest 1B to Posttest 1, Pretest 2 to Posttest 2B and Pretest 3 to Posttest 3B allowed for the determination of differences that occurred within sessions. While there was not an anticipated significant difference occurring during Session 1, it was included, because it provided information on the immediate effects of using the software. The identified comparisons were made for each of the three dependent measures.

Table 3

Data Analysis Comparisons Completed to Determine Effects on Writing

Comparisons		Number of Words (NW)	Spelling Errors (SE)	Mean T-Unit Length (MTUL)
Pretest 1B	Posttest 3B			
Pretest 1B	Posttest 2B			
Pretest 1B	Posttest 1			
Pretest 2	Posttest 2B			
Pretest 2	Posttest 3B			
Pretest 3	Posttest 3B			

While the primary research question considered whether students with DWE would demonstrate improvement in the writing process of translating, when using the software applications of word prediction and text-to-speech in combination, a related secondary question existed. The question was whether the participants demonstrated consistent performance across the three sessions. This question has relevance, in that inconsistent performance would affect the comparisons being made between pretest and posttest scores in different sessions. The

comparisons necessary to determine consistent performance are comparisons of pretest scores to each other and posttest scores to each other. The proposed comparisons to answer the question of consistent performance are listed in Table 4.

Table 4

Data Analysis Comparisons Completed to Determine Consistency in Participant Performance

Comparisons		Number of Words (NW)	Spelling Errors (SE)	Mean T-Unit Length (MTUL)
Pretest 1B	Pretest 2			
Pretest 1B	Pretest 3			
Pretest 2	Pretest 3			
Posttest 1	Posttest 2B			
Posttest 1	Posttest 3B			
Posttest 2B	Posttest 3B			

Data was analyzed using Microsoft Excel 2011 (Microsoft Corp; Redmond, Washington). using the Wilcoxon Signed Rank Test (WSRT). The WSRT is a nonparametric test that is appropriate for use with small samples when the underlying distribution characteristics are unknown. Instead of testing the difference between means of two populations, the WSRT is based on median ranks (Portney & Watkins, 2009). The hypothesis of no improvement was tested in each of the chosen comparisons with a $p<.05$ chosen as a basis for rejecting that hypothesis in favor of a significant improvement.

Results

The purpose of this study was to determine if the word prediction combined with text-to-speech software would have any effect on the writing of students with DWE. Data was collected and analyzed for 10 participants.

Table 5 details the group median scores from selected evaluations for the dependent measures NW, SE and MTUL.

Table 5

Median scores for Number of Words (NW), Spelling Errors (SE) and Mean T-Unit Length (MTUL)

Evaluation	Number of Words (NW) Median Score	Spelling Errors (SE) Median Score	Mean T-Unit Length (MTUL) Median Score
Pretest1B	102.5	14.0	9.7
Pretest 2	110.0	11.5	10.6
Pretest 3	104.5	11.0	11.3
Posttest 1	86.5	5.0	11.0
Posttest 2B	99.0	5.0	11.9
Posttest 3B	104.5	3.5	12.0

Table 6 provides a summary of the WSRT results for the pretest posttest comparisons that were made for the NW dependent measure. Each of the comparisons made for NW revealed significant improvement in that the median scores for the posttests was less then the pretests. The results indicate that the combination of word prediction and text-to-speech resulted in the production of writing samples with fewer words.

Table 6
Comparison of Pretest to Posttest Evaluations for Number of Words (NW)

	Median Score		Median Score	Significant *
Pretest 1B	102.5	Posttest 3B	85.5	Yes
Pretest 1B	102.5	Posttest 2B	99	Yes
Pretest 1B	102.5	Posttest 1	86.5	Yes
Pretest 2	102.5	Posttest 2B	99	Yes
Pretest 3	104.5	Posttest 3B	85.5	Yes

* $p<.05$

Table 7 provides a summary of all of the pretest posttest comparisons that were made for the dependent measure SE. Analysis revealed that each of the comparisons made for SE resulted in median posttest scores that were significantly less than the pretest scores. These results indicate that the use of word prediction and text-to-speech resulted in writing samples with fewer spelling errors.

Table 7

Comparison of Pretest to Posttest for Spelling Errors (SE)

	Median Score		Median Score	Significant *
Pretest 1B	14.0	Posttest 3B	3.5	Yes
Pretest 1B	14.0	Posttest 2B	5.0	Yes
Pretest 1B	14.0	Posttest 1	5.0	Yes
Pretest 2	11.5	Posttest 2B	5.0	Yes
Pretest 3	11.0	Posttest 3B	3.5	Yes

* $p<.05$

Table 8 provides a summary of all of the pretest posttest comparisons that were made for the dependent measure MTUL. Statistical analysis revealed that the difference observed between Pretest 1B and Posttest 3B was the only comparison significant for MTUL. The remaining differences were observed to be the expected direction of improvement, but the gains were not statistically significant. These results indicate that the combination of word prediction and text-to-speech can impact writing maturity as measured by MTUL.

Table 8

Comparison of Pretest to Posttest for Mean T-Unit Length (MTUL)

	Median Score		Median Score	Significant *
Pretest 1B	9.7	Posttest 3B	12.0	Yes
Pretest 1B	9.7	Posttest 2B	11.9	No
Pretest 1B	9.7	Posttest 1	11.0	No
Pretest 2	10.6	Posttest 2B	11.9	No
Pretest 3	11.3	Posttest 3B	12.0	No

* $p<.05$

A secondary question related to this study was whether or not the participants performed consistently across the three sessions. Consistent performance would support the differences noted in pretest and posttest scores being attributed to the word prediction and text-to-speech combination rather than random performance.

Table 9 provides a summary of all of the pretest to pretest comparisons and posttest to posttest comparisons that were made for the dependent measure NW. There were no statistically significant differences observed between NW scores in posttest to posttest comparisons. These results indicate that the participants' performance for the dependent measure of NW was consistent over the three sessions.

Table 9

Comparison of Pretest to Pretest and Posttest to Posttest for Number of Words (NW)

	Median Score		Median Score	Significant *
Pretest 1B	102.5	Pretest 2	110.0	No
Pretest 1B	102.5	Pretest 3	104.5	No
Pretest 2	110.0	Pretest 3	104.5	No
Posttest 1	86.5	Posttest 2B	99.0	No
Posttest 1	86.5	Posttest 3B	85.5	No
Posttest 2B	99.0	Posttest 3B	85.5	No

* $p<.05$

Table 10 provides a summary of the pretest to pretest comparisons and posttest to posttest comparisons that were made for the dependent measure SE. The comparisons made for SE revealed that there was a statistical difference between Pretest 1B and Pretest 2. The remainder of the pretest to pretest comparisons and posttest to posttest comparisons indicated no significant differences. These results indicate that the participants' performance for the dependent measure of SE was generally consistent over the three sessions.

Table 10

Comparison of Pretest to Pretest and Posttest to Posttest for Spelling Errors (SE)

	Median Score		Median Score	Significant *
Pretest 1B	14.0	Pretest 2	11.5	Yes
Pretest 1B	14.0	Pretest 3	11.0	No
Pretest 2	11.5	Pretest 3	11.0	No
Posttest 1	5.0	Posttest 2B	5.0	No
Posttest 1	5.0	Posttest 3B	3.5	No
Posttest 2B	5.0	Posttest 3B	3.5	No

* $p<.05$

Table 11 provides a summary of all of the pretest to pretest and posttest to posttest comparisons made for the dependent measure MTUL. The evaluation comparisons made for MTUL revealed that there was no significant difference between pretest to pretest scores nor was there any significant differences between posttest to posttest scores. These results indicate that the participants' performance for the dependent measure of MTUL was consistent over the three sessions.

Analysis of the pretest to pretest and posttest to posttest scores for the three dependent variables indicated consistent performance by the participants. This consistency supports attributing the differences noted in pretest and posttest scores to the word prediction and text-to-speech combination rather than random performance.

Table 11

Comparison of Pretest to Pretest and Posttest to Posttest for Mean T-Unit Length (MTUL)

	Median Score		Median Score	Significant *
Pretest 1B	9.7	Pretest 2	10.6	No
Pretest 1B	9.7	Pretest 3	11.3	No
Pretest 2	10.6	Pretest 3	11.3	No
Posttest 1	11.0	Posttest 2B	11.9	No
Posttest 1	11.0	Posttest 3B	12.0	No
Posttest 2B	11.9	Posttest 3B	12.0	No

* $p<.05$

Discussion

The purpose of this study was to investigate the impact that the combination of word prediction and text-to-speech features in the software program WordQ had on the writing process of translating in students diagnosed with DWE. The overall results showed general improvement in translating using the combination of word prediction and text-to-speech as measured by SE, NW and MUTL. The number of spelling errors SE was observed to decrease. The amount of words written NW was observed to decrease. The syntactic maturity measure MUTL was observed to increase.

Spelling Errors

The findings of the study related to spelling accuracy are consistent with previous studies (Evmenova et al., 2010; Cullen et al., 2008; Handley-Moore et al, 2003; MacArthur, 1998; Silio` & Barbetta, 2010). The observed decrease in spelling errors, when using word prediction combined with text-to-speech, lends further support to the existing evidence for its use as a best practice method to address the spelling problems experienced by students who have learning disabilities.

The combination of word prediction and text-to-speech appeared to be critical in regards to spelling, as text-to-speech was often necessary to enable the participants to accurately select and confirm selection of words that appeared on the word list generated by the word prediction feature. The following example illustrates the contribution that word prediction, when combined with text-to-speech, makes to reducing spelling errors. The first sample was written by one of the participants without the use of word prediction and text-to-speech. The second sample was written during the same session using the word prediction and text-to-speech features in WordQ.

the boe is simn is simn ni the oine the bob simn with a sokr and fishs a sesl and bubls wass ni the sokr had is a hmr

that girl is sliding down the hill and the boy rod

The participant who created these writing samples was observed to methodically try to spell a word and then find it by pointing to words in the word list and listening to them. If she did not hear the word she was looking for, she would change the spelling and go back to the list.

Spelling has been identified as a key problem experienced by students with DWE during the

writing process of translating (Berninger, 1991). The findings of this research suggest that word prediction combined with text-to-speech is effective in addressing spelling problems exhibited by students with DWE.

Amount of Words

The finding that the participants in this study produced fewer words is consistent with previous studies (Handley-Moore et al.; 2003MacArthur, 1998,1999) related to the use of word prediction combined with text-to-speech, but not with the most recent studies (Evmenova et al., 2010; Cullen et al., 2008; Silio` & Barbetta, 2010).

A difference between this study and those most recent studies that identified increases in number of words produced were possibly due to the design of the studies (Evmenova et al., 2010; Cullen et al., 2008; Silio` & Barbetta, 2010). Evmenova et al. and Silio` & Barbetta used true multiple baseline series designs. Because of this, the participants completed several more writing samples than the participants in this study. Cullen et al. used a modified multiple baseline series design, that also included typing many more writing samples than were completed in this study. Increased experience both with writing and the use of word prediction, when combined with text-to-speech, may have contributed to the differences noted.

A factor that should be considered as possibly influencing the number of words produced is the improvement demonstrated by the participants in the area of spelling. To make improvements in spelling, the participants had to spend time looking at the words generated on the lists, sometimes pointing and listening to words to determine if it was the word they were trying to spell. Using the word list in this way is time-consuming, and might have the effect of producing fewer words within a certain span of time.

It is recognized that students with DWE experience a number of problems with the writing process of translating. While word processing and word prediction combined with text-to-speech appear to directly address the challenges of poor handwriting and spelling, they do not directly address the challenges of holding information in working memory, or converting ideas into words. Studies of persons with physical disabilities have indicated that word prediction can contribute to producing fewer keystrokes, but it does not contribute to typing faster. Koester & Levine (1996)

indicated that the cognitive and perceptual loads associated with word prediction result in an increase in typing time that negates the benefits of decreased keystrokes. Anson (1993) indicated that an additional concern related to the use of word prediction, and the number of words produced on the word list, was the time required to visually search the word list to determine if the word attempting to be spelled was on the list.

Another factor that may have contributed to the participants producing fewer words is the nature of the Functional Training sessions. During these sessions, the participants were asked to write sentences made up of commonly misspelled words. These activities required the students to consistently use the word list combined with text-to-speech to look for specific words. This approach may have carried over to the intervention sessions, resulting in fewer words produced. All of these factors could potentially contribute to fewer words being typed when using word prediction combined with text-to-speech.

Maturity of Writing

Review of the data related to maturity of writing indicated improvement from the first session to the last session, but did not demonstrate significant differences, when comparisons were made within sessions. This finding suggests that using word prediction in combination with text-to-speech may assist students who have DWE to develop syntactic maturity in their writing over time. Reasoning for this may be that, over the course of the three sessions, the participants developed increased skill and comfort in the use of the software, which contributed to the maturity of their writing.

No other studies were located that have used MTUL to assess the maturity of writing when using word prediction in combination with text-to-speech on the writing competence of students with DWE. Silio` & Barbetta (2010) measured the number of T-units in their study of Hispanic grade school boys with specific learning disability. Their findings reported that all of the students increased their mean number of T-units when using word prediction alone and in combination with text-to-speech. An increase in the number of T-units in itself is not an indicator of increased syntactic maturity (Hunt, 1965). An increase in the number of T-units could possibly indicate a decrease in writing maturity, as it might reflect a greater number of shorter, less complex

sentences, and possibly a corresponding decrease in MTUL. Silio` & Barbetta suggest that word prediction and text-to-speech may enable students to concentrate more on the intended message and less on writing mechanics. The ability to concentrate more on the message may also contribute to increased sentence maturity.

Limitations

There are several limitations to his study, which affect the ability to generalize the results. Each of these limitations is described below.

Participants. The primary limitation of the study was related to the participants. All participants in this study had a diagnosis of disorder of written expression (DWE). The narrowness of this sample limits generalization of the findings to other diagnoses, or problems specific to written expression. An associated concern is that it was unknown if any of the participants had additionally diagnoses that may have contributed to difficulties they experienced with written expression. An additional limitation concerning the participants is that they were all of the same ethnicity, and all attended Christian parochial schools of a specific denomination. Because of this, the findings of this study have limited generalizability to students with more diverse cultural and educational backgrounds.

Type of Writing. The present study focused specifically on the writing process of translating while completing first draft narratives based on picture-based prompts. The dependent measures, writing prompts, and training sessions of this study were all geared toward addressing the writing process of translating, and did not address the processes of planning or reviewing. This narrowed focus does not reflect the complexities of the broader writing process, which include both planning and reviewing. These factors limit the generalizability of the study to other writing processes and with other types of writing.

WordQ. A factor that limits the ability to generalize the results of this study is the software used during the intervention phases. WordQ represents just one of many different software products that include word prediction and text-to-speech. Other word prediction and text-to-speech software programs may not provide the same results found in this study.

Study Design. The design of this study is a limitation that must be acknowledged. The use of a modified multiple baseline case series design presented the possibility of decreased internal validity. The collection of data over a three-week period of time increased the possibility that observed changes were influenced by the effects of history and maturation. Additionally, the study did not move the participants from baseline to intervention phases one at time, which decreased the possibility that observed changes were due to the intervention, and not due to another factor.

Recommendations

To build on the findings of this study, future research should consider application of word prediction and text-to-speech to all phases of writing and to different types of writing. While word prediction combined with text-to-speech appears directly suited for the process of translating, it can also have application with planning and reviewing. This concept can be further expanded to also include the completion of research that incorporates individualized instruction and customization of software settings to meet the unique needs of the participants.

The use of word prediction combined with text-to-speech software to address problems associated with writing is considered a compensatory approach. While compensatory measures aid in addressing the limitations demonstrated by students with disabilities, they do not teach the student about specific aspects of writing. To best meet the needs of students who experience problems with writing, remedial instruction should be paired with compensatory strategies like word prediction combined with text-to-speech. Additionally, integrating the use of word prediction combined with text-to-speech into a variety of academic subjects should also be considered.

Incorporating expanded assessment of the effects of word prediction combined with text-to-speech is recommended in future research. Quantitative measures, such as tallying number of words and spelling errors, do not necessarily reflect the broader impact that word prediction combined with text-to-speech has on the writing competence of students with DWE. Future research should include measures that assess the impact the software has on a student's quality of the writing and overall academic performance.

A final recommendation is that short video tutorials be combined with active learning to teach students to use word prediction combined with text-to-speech software. The two video sessions that were used in this research appeared to be an effective method for completing instruction in the use of the software. All of the participants demonstrated effective use of the primary features of the software using this method.

Implications

Based on the results of this study and those of past studies, teachers and other professionals who work with students who demonstrate problems with written expression should consider using word prediction combined with text-to-speech to aid the process of writing. Specifically, this research supports the use of the software to address problems with spelling. Software that features word prediction combined with text-to-speech is now widely available, priced reasonably, and offered in versions for multiple platforms, including touchscreen tablets.

This study demonstrated that students with a diagnosis of DWE, can be taught to use the software in a short amount of time, and benefit from its use. Broader application of the software within schools will allow students the opportunities to benefit from it. Future research can explore how to best integrate technologies, like word prediction combined with text-to-speech software, into the daily routines of students, to assess its impact on academic outcomes.

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Appendix A
Recruitment Letter

Dear Parent,

The purpose of this letter is to introduce myself to you and inform you about a research study being conducted through the University of Missouri- St. Louis and Maryville University. The purpose of this research is to determine if assistive technology software can assist students who experience difficulty with writing.

My name is Bob Cunningham and I am an occupational therapist and an Assistant Professor in the Occupational Therapy Program at Maryville University. I am also a doctoral student at the University of Missouri –St. Louis. The research study being described is part of the requirements of my doctoral program. As a therapist, I specialize in the practice of assistive technology and I am interested in better understanding how it might benefit students. Assistive technology in this instance refers to computer software that can assist students with completing writing tasks.

The Resource Room teacher at your child's school has indicated that your child has an appropriate Individual Education Plan (IEP) that qualifies them for this study and that they may possibly benefit from using assistive technology to aid them with writing.

I would like to ask you to agree to allow your child to be a part of this research study. Your child's participation will involve them being trained to use the assistive technology software program WordQ and complete writing tasks with and without the WordQ software. Specifically, your child will be asked to select a picture from choices provided and then asked to write about that picture by typing on a computer. The writing tasks that your child participates in will last 10 minutes. Each session will include three separate writing tasks.

The research will be conducted on three consecutive Saturdays. The sessions will start at 10:00AM and will last approximately 1½ hours. Each session will include completing three separate writing responses. The research will be conducted in the Maryville University Assistive Technology Lab, which is located in the Chapel Hill Office Building. The address for the Assistive Technology Lab is 12935 North 40 Drive, #100, St. Louis, MO 63141.

For participating in the study, your child will receive a 10-dollar gift card. If your child participates in all three sessions they will also receive a copy of the WordQ software used during the study at no cost.

Please note that any information collected about your child will be kept strictly confidential. Writing samples created by your child will not have their name on it. Any reporting of the findings will use an alias in place or your child's name.

I invite you to contact the Resource Teacher or myself with any questions you might have about this study. Please be assured if you choose to not have your child participate in the study, it will have no negative effects in regards to any services they may be currently receiving at their school.

Thank you for your consideration. If you are willing to allow your child to be part of this study, please complete the enclosed Registration Form. On the form indicate the dates you would like to participate, complete the contact information and return it in the enclosed stamped envelope. I have also enclosed a Consent Form for your review.

Once I have received the Registration Form, I will contact you with information about the study.

Sincerely,

Bob Cunningham, MS, OT/L, ATP

314-849-0068

314-398-4907

rcunningham@maryville.edu

Appendix B
Informed Consent

Informed Consent for Child Participation in Research Activities
The Effects of Word Prediction and Text-to-Speech on the Writing Process of Translating

Participant _____ HSC Approval Number _240470-2

Principal Investigator Bob Cunningham PI's Phone Number 314-398-4907

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1. Your child is invited to participate in a research study conducted by Bob Cunningham under the supervision of Dr. Patricia Koptez. The purpose of this research is to determine if assistive technology software can assist students who experience difficulty with writing.

2. a) Your child's participation will involve being trained to use the assistive technology software program WordQ and engage in writing tasks with and without the WordQ software.

Specifically, your child will be asked to select a picture from choices provided and then asked to write about that picture by typing on computer. Some of the writing responses will involve the use of the WordQ software and some will only involve the use of a word processing program.

Approximately 20 students may be involved in this research. The research will be conducted using groups of five children per session.

b) The research will be conducted on three consecutive Saturdays. The sessions will start at 10:00AM and 1:00PM. The sessions will last approximately 1½ hours. The writing tasks that your child completes will last 10 minutes each. Each Saturday session will include completing three separate writing responses.

The research will be conducted in the Maryville University Assistive Technology Lab, which is located in the Chapel Hill Office Building. The address for the Assistive Technology Lab is:

Maryville Occupational Therapy Program
12935 North 40 Drive, #100,
St. Louis, MO 63141
314-398-4907

All students who participate in the research project will receive a 10-dollar gift card at the end of the first session for their efforts. If a student participates in all three sessions, they will receive a copy of the WordQ software at no cost.

3. There may be certain risks or discomforts to your child associated with this research. They include that your child may become frustrated in learning to use the software or completing the writing tasks. To minimize the risk of your child becoming frustrated, the writing sessions will be implemented in a manner aimed at limiting the possibility of this occurring. To increase the appeal of the writing tasks, the students will be asked to select the visually based writing prompt of their choice. An additional measure that will be taken to limit frustration on the part of the students will be to limit the length of the extemporaneous writing sessions to 10 minutes each.

4. The possible benefits to your child from participating in this research are that your student may find that WordQ software aids their ability to complete writing tasks.

5. Your child's participation is voluntary and you may choose not to let your child participate in this research study or to withdraw your consent for your child's participation at any time. Your child may choose not to answer any questions that he or she does not want to answer. You and your child will NOT be penalized in any way should you choose not to let your child participate or to withdraw your child.

6. We will do everything we can to protect your child's privacy. By agreeing to let your child participate, you understand and agree that your child's data may be shared with other researchers and educators in the form of presentations and/or publications. In all cases, your child's identity will not be revealed. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for Human Research Protection). That agency would be required to maintain the confidentiality of your child's data.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Bob Cunningham (314-398-4907) or the Faculty Advisor, Dr. Patricia Kopetz (314-516-4885) You may also ask questions or state concerns regarding your child's rights as a research participant to the Office of Research Administration, at 314-516-5897.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my child's participation in the research described above.

Parent's/Guardian's Signature	Date	Parent's/Guardian's Printed Name

Child's Printed Name

Signature of Investigator or Designee	Date	Investigator/Designee Printed Name

Appendix C
Research Protocol Sessions 1, 2, & 3

Dissertation Research Protocol
Session 1

1. Explain Study
    1.1. Purpose of the study
        1.1.1. *The purpose of this study is to see if word prediction and text to speech software helps students complete writing tasks*. We will be comparing how well you write without the WordQ software and how you write while using it. You will be asked to write 9 different times using a computer. Each time you write it will be for only 10 minutes.

    1.2. Get assent.
        1.2.1. Before we can start, you need to agree to participate. Your parents have said it's okay for you to take part in this project, but you also need to say its ok. Even though your parents have said its ok, you don't have to do it. You are allowed to stop participating at any time and nothing will happen to you if you do.
        1.2.2. Have student sign assent form

2. Baseline Writing Sample (Pretest 1A)
    2.1. Explain the writing task.
        2.1.1. *I would like you to complete a writing sample for me. You will type on the computer to complete this activity. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can*.
        2.1.2. *Here are two pictures. Please choose the one that you want to write about*.
            2.1.2.1. Student chooses picture
        2.1.3. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.
        2.1.4. *When I say "Begin" you will have 10 minutes to write about the picture*.
        2.1.5. *I will let you know when you have 2 minutes left to write. Do you have any questions*?
    2.2. Set up the student at the computer.
        2.2.1. You may begin writing
    2.3. Writing prompts
        2.3.1. "You have 2 minutes left to write"
    2.4. (offer prompts after 15 seconds of no writing)
        2.4.1. "Can you think of anything else to add to your story?"
        2.4.2. "Have you written about everybody in the picture?"
        2.4.3. "You can read over your story and add more."

2.4.4. “Is there anything else you think is happening in the picture?”

2.5. Provide feedback

2.5.1. You did great with that writing assignment. Now you are going to begin to learn about the WordQ software.

3. Introduce WordQ Software

3.1. Show video “WordQ SpeakQ Overview”

3.2. Ask if they have questions

4. Baseline Writing Sample (Pretest 1B)

4.1. Explain the writing task.

4.1.1. *I would like you to complete another writing sample for me. You will type on the computer to complete this activity. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don’t worry about how good it is, just do the best you can*.

4.1.2. *Here are two pictures. Please choose the one that you want to write about*.

4.1.2.1. Student chooses picture

4.1.3. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

4.1.4. *When I say “Begin” you will have 10 minutes to write about the picture*.

4.1.5. *I will let you know when you have 2 minutes left to write. Do you have any questions*?

4.2. Set up the student at the computer.

4.2.1. You may begin writing

4.3. Writing prompts

4.3.1. “*You have 2 minutes left to write*”

4.4. (offer prompts after 15 seconds of no writing)

4.4.1. “Can you think of anything else to add to your story?”

4.4.2. “Have you written about everybody in the picture?”

4.4.3. “You can read over your story and add more.”

4.4.4. “Is there anything else you think is happening in the picture?”

4.5. Provide feedback

4.5.1. You did great with that writing assignment. Now you are going to begin to learn how to use the Wordq software.

5. Video Training 1

5.1. Explain the training task

5.1.1. You will now be watching some videos that explain how to use the software. After you finish watching them, you will have time to practice. I will be available to answer any questions you have about the software.

5.1.2. Open WordQ

5.2. Observe the videos and try it out (Check headphones and volume)

5.2.1. Turning functions on and off

5.2.1.1. Open file Practice one

5.2.1.2. "The dog was (turn on WP) move up and down word list

5.2.1.3. Have them choose a word from the list generated (use mouse or arrow keys)

5.2.1.4. Turn on Speech feature. Use it to hear words when they are typed and words on the prediction list.

5.2.2. Three ways to choose words

5.2.2.1. Open file Practice 2

5.2.2.2. The rain started …… Use mouse to select choice from wp list

5.2.2.3. The man stood up and …… Use number keys to select a choice from wp list

5.2.2.4. My favorite ice cream flavor is…. Use arrow keys to select a choice from wp list

5.2.3. Selecting homonyms

5.2.3.1. Open file Practice 3

5.2.3.2. The ……. Backspace to the and see the definition there versus their next

5.2.3.3. He has good common cense/sense

5.2.4. Leave word box in place

5.2.4.1. Instruct the students that I will help them make it stationary if they prefer

5.2.5. Proof reading

5.2.5.1. Open file Practice 4

5.2.5.2. Click the read button to listen to the first sentence.

5.2.5.3. Use arrow up and down to select and read the next sentence

5.2.5.4. Use right and left arrow to listen to one word at a time

6. Writing sample (Posttest 1)

6.1. Explain the writing task.

6.1.1. I would like you to complete a writing sample for me. You will type on the computer and use the WordQ software to help you. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can.

6.1.2. Here are two pictures. Please choose the one that you want to write about.

6.1.3. Student chooses picture

6.1.4. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

6.1.5. When I say “Begin” you will have 10 minutes to write about the picture.

6.1.6. I will let you know when you have 2 minutes left to write. Do you have any questions?

6.2. Set up the student at the computer.

6.2.1. You may begin writing

6.3. Writing prompts

6.3.1. “You have 2 minutes left to write”

6.3.2. (offer prompts after 15 seconds of no writing)

6.3.2.1. “Can you think of anything else to add to your story?”

6.3.2.2. “Have you written about everybody in the picture?”

6.3.2.3. “You can read over your story and add more.”

6.3.2.4. “Is there anything else you think is happening in the picture?”

6.4. Provide feedback

6.4.1. You did great with that writing assignment. Now you are going to work with Morgan on another computer. She is going to help you begin to learn how to use the Wordq Speakq software.

Dissertation Research Protocol
Session 2

1. Explain Study

1.1. Review Purpose of the study

1.1.1. *The purpose of this study is to see if word prediction and text to speech software helps students complete writing tasks*. We will be comparing how well you write without the WordQ software and how you write while using it.

2. Baseline Writing Sample (Pretest 2)

2.1. Explain the writing task.

2.1.1. *I would like you to complete a writing sample for me. You will type on the computer to complete this activity. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can*.

2.1.2. *Here are two pictures. Please choose the one that you want to write about*.

2.1.2.1. Student chooses picture

2.1.3. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

2.1.4. *When I say "Begin" you will have 10 minutes to write about the picture*.

2.1.5. *I will let you know when you have 2 minutes left to write. Do you have any questions*?

2.2. Set up the student at the computer.

2.2.1. You may begin writing

2.3. Writing prompts

2.3.1. "You have 5 minutes left to write"

2.4. (offer prompts after 15 seconds of no writing)

2.4.1. "Can you think of anything else to add to your story?"

2.4.2. "Have you written about everybody in the picture?"

2.4.3. "You can read over your story and add more."

2.4.4. "Is there anything else you think is happening in the picture?"

3. Video Training 2

3.1. Explain the training task

3.1.1. You will now be watching some videos that explain how to use the software. After you finish watching them, you will have time to practice. I will be available to answer any questions you have about the software.

3.1.2. Open WordQ

3.2. Observe the videos and try it out (Check headphones and volume)

3.2.1. Turning functions on and off

3.2.1.1. Open file Practice one

3.2.1.2. "The dog was (turn on WP) move up and down word list

3.2.1.3. Have them choose a word from the list generated (use mouse or arrow keys)

3.2.1.4. Turn on Speech feature. Use it to hear words when they are typed and words on the prediction list.

3.2.1.4.1. Ask the question: *When might you want to turn the WP or the Speech feature off?*

3.2.2. Adjusting Sound feedback

3.2.2.1. Demonstrate that speech can be adjusted to read every word as type or just sentences.

3.2.2.2. Type a sentence with speech set at read each word. "The cat ran fast"

3.2.2.3. Type a sentence with speech set at read each sentence. "The cat run fast".

3.2.3. Three ways to choose words

3.2.3.1. Open file Practice 2

3.2.3.2. The rain started …… Use mouse to select choice from wp list

3.2.3.3. The man stood up and …… Use number keys to select a choice from wp list

3.2.3.4. My favorite ice cream flavor is…. Use arrow keys to select a choice from wp list

3.2.4. Selecting homonyms

3.2.4.1. Open file Practice 3

3.2.4.2. The ……. Backspace to the and see the definition there versus their next

3.2.4.3. He has good common cense/sense

3.2.5. Leave word box in place

3.2.5.1. Instruct the students that I will help them make it stationary if they prefer

3.2.6. Proof reading

3.2.6.1. Open file Practice 4

3.2.6.2. Click the read button to listen to the first sentence.

3.2.6.3. Use arrow up and down to select and read the next sentence

3.2.6.4. Use right and left arrow to listen to one word at a time

3.2.6.5.

3.2.6.5.1. Ask the question: *What strategy might you use to help you with proof reading?*

4. Writing sample (Posttest 2a)

4.1. Explain the writing task.

4.1.1. I would like you to complete a writing sample for me. You will type on the computer and use the WordQ software to help you. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can.

4.1.2. Here are two pictures. Please choose the one that you want to write about.

4.1.3. Student chooses picture

4.1.4. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

4.1.5. When I say "Begin" you will have 10 minutes to write about the picture.

4.1.6. I will let you know when you have 2 minutes left to write. Do you have any questions?

4.2. Set up the student at the computer.

4.2.1. You may begin writing

4.3. Writing prompts

4.3.1. "You have 2 minutes left to write"

4.3.2. (offer prompts after 15 seconds of no writing)

4.3.2.1. "Can you think of anything else to add to your story?"

4.3.2.2. "Have you written about everybody in the picture?"

4.3.2.3. "You can read over your story and add more."

4.3.2.4. "Is there anything else you think is happening in the picture?"

4.4. Provide feedback

4.4.1. You did great with that writing assignment. Now you are going to work with Morgan on another computer. She is going to help you begin to learn how to use the Wordq Speakq software.

5. Functional Training 2

5.1. Explain the training task

5.1.1. This time I will give you some writing tasks to complete using WordQ software. The purpose is for you to practice using it.

5.1.2. Open WordQ and WordPad

5.2. Complete the following tasks.

5.2.1. Write Sentences

5.2.1.1. Bill's attendance was requested at the safety planning meeting.

5.2.1.2. Jim chose to settle the argument by looking up the spelling for the word jealousy in the dictionary.

5.2.1.3. Steve thought that a family calendar was an incredible idea.

5.2.1.4. Jill was surprise when she was asked to share her knowledge of the mysterious disease.

5.2.1.5. QUESTION: What strategies worked for you during this exercise?

6. Writing sample (Posttest 2A)

6.1. Explain the writing task.

6.1.1. I would like you to complete a writing sample for me. You will type on the computer and use the WordQ software to help you. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can.

6.1.2. Here are two pictures. Please choose the one that you want to write about.

6.1.3. Student chooses picture

6.1.4. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

6.1.5. When I say "Begin" you will have 10 minutes to write about the picture.

6.1.6. I will let you know when you have 2 minutes left to write. Do you have any questions?

6.2. Set up the student at the computer.

6.2.1. You may begin writing

6.3. Writing prompts

6.3.1. "You have 2 minutes left to write"

6.3.2. (offer prompts after 15 seconds of no writing)

6.3.2.1. "Can you think of anything else to add to your story?"

6.3.2.2. "Have you written about everybody in the picture?"

6.3.2.3. "You can read over your story and add more."

6.3.2.4. "Is there anything else you think is happening in the picture?"

6.4. Provide feedback

6.4.1. You did great with that writing assignment. Now you are going to work with Morgan on another computer. She is going to help you begin to learn how to use the Wordq Speakq software.

Dissertation Research Protocol
Session 3

1. Explain Study
    1.1. Review Purpose of the study
        1.1.1. *The purpose of this study is to see if word prediction and text to speech software helps students complete writing tasks*. We will be comparing how well you write without the WordQ software and how you write while using it.

2. Baseline Writing Sample (Pretest 3)
    2.1. Explain the writing task.
        2.1.1. *I would like you to complete a writing sample for me. You will type on the computer to complete this activity. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can*.
        2.1.2. *Here are two pictures. Please choose the one that you want to write about*.
            2.1.2.1. Student chooses picture
        2.1.3.Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.
        2.1.4. *When I say "Begin" you will have 10 minutes to write about the picture*.
        2.1.5. *I will let you know when you have 2 minutes left to write. Do you have any questions*?
    2.2. Set up the student at the computer.
        2.2.1. You may begin writing
    2.3. Writing prompts
        2.3.1. "You have 5 minutes left to write"
    2.4. (offer prompts after 15 seconds of no writing)
        2.4.1. "Can you think of anything else to add to your story?"
        2.4.2. "Have you written about everybody in the picture?"
        2.4.3. "You can read over your story and add more."
        2.4.4. "Is there anything else you think is happening in the picture?"

3. Writing sample (Posttest 3A)
    3.1. Explain the writing task.
        3.1.1. I would like you to complete a writing sample for me. You will type on the computer and use the WordQ software to help you. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can.
        3.1.2. Here are two pictures. Please choose the one that you want to write about.
        3.1.3. Student chooses picture
        3.1.4. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

3.1.5. When I say “Begin” you will have 10 minutes to write about the picture.

3.1.6. I will let you know when you have 2 minutes left to write. Do you have any questions?

3.2. Set up the student at the computer.

3.2.1. You may begin writing

3.3. Writing prompts

3.3.1. “You have 2 minutes left to write”

3.3.2. (offer prompts after 15 seconds of no writing)

3.3.2.1. “Can you think of anything else to add to your story?”

3.3.2.2. “Have you written about everybody in the picture?”

3.3.2.3. “You can read over your story and add more.”

3.3.2.4. “Is there anything else you think is happening in the picture?”

3.4. Provide feedback

3.4.1. You did great with that writing assignment. Now you are going to work with Morgan on another computer. She is going to help you begin to learn how to use the Wordq Speakq software.

4. Functional Training 3

4.1. Explain the training task

4.1.1. I want to see what you remember about how WordQ works. We will briefly review its main features.

4.1.2. Open WordQ

4.2. Turning functions on and off

4.2.1. How do I turn on word prediction? Have the students explain how and demonstrate on the screen.

4.2.2. How do you turn on the Speech feature? Have the students explain how and demonstrate on the screen.

4.3. Adjusting Sound feedback

4.3.1. What are my choices for speech feedback? Do I have to have it read every word? Demonstrate that speech can be adjusted to read every word as type or just sentences.

4.3.2. Type a sentence with speech set at read each word. “The cat ran fast”

4.3.3. Type a sentence with speech set at read each sentence. “The cat run fast”.

4.4. Three ways to choose words

4.4.1. What are the three ways to choose words? Review them as the students name them.

4.5. Proof reading

4.5.1. How do I listen to my work after I finish writing? What are the different ways I can have it read?

4.5.2. Use arrow up and down to select and read the next sentence

4.5.3. Use right and left arrow to listen to one word at a time

4.5.3.1. Ask the question: *What strategy might you use to help you with proof reading?*

4.6. Write Sentences

4.6.1. This time I will give you some writing tasks to complete using WordQ software. The purpose is for you to practice using it.

4.6.1.1. I always have enough neighbors to assist me with really peculiar problems.

4.6.1.2. My imaginary companion enjoyed beautiful clothes and foreign magazines.

4.6.1.3. QUESTION: What strategies worked for you during this exercise?

4.7. Find the spelling errors.

4.7.1. Open Practice 5

4.7.2. Use the speech and word prediction features to find the spelling errors and correct them.

4.7.2.1. I can heer when I hav speeled things rong. I can also heer whn I have use bad grammars.

5. Writing sample (Posttest 3B)

5.1. Explain the writing task.

5.1.1. I would like you to complete a writing sample for me. You will type on the computer and use the WordQ software to help you. You will write about a picture that you choose. When I say start writing, you will have 10 minutes to write about what is happening in the picture. Don't worry about how good it is, just do the best you can.

5.1.2. Here are two pictures. Please choose the one that you want to write about.

5.1.3. Student chooses picture

5.1.4. Look at the picture you selected and think about what is happening in the picture. Try to imagine a story about what is happening. Write anything you like about this picture. Use your imagination.

5.1.5. When I say "Begin" you will have 10 minutes to write about the picture.

5.1.6. I will let you know when you have 2 minutes left to write. Do you have any questions?

5.2. Set up the student at the computer.

5.2.1. You may begin writing

5.3. Writing prompts

5.3.1. "You have 2 minutes left to write"

5.3.2. (offer prompts after 15 seconds of no writing)

5.3.2.1. "Can you think of anything else to add to your story?"

5.3.2.2. "Have you written about everybody in the picture?"

5.3.2.3. "You can read over your story and add more."

5.3.2.4. "Is there anything else you think is happening in the picture?"

5.4. Provide feedback

5.4.1. You did great with that writing assignment. Now you are going to work with Morgan on another computer. She is going to help you begin to learn how to use the Wordq Speakq software.

Appendix D
Writing Sample Scoring Protocol

Total Number of Words

- Count both correctly and incorrectly spelled words.
- Proper nouns are counted as words.
- Numerals (unless they were spelled out) were not counted as words.
- Inadvertent letters standing alone are not counted as words.

Correctly Spelled Words

- Mark each word that is spelled incorrectly. One word misspelled three times is counted as three mistakes.
- Words written in the incorrect tense or form are counted as spelling errors.
- Homonyms are considered misspellings (too cats).
- Words that were spelled correctly but are inappropriately used within the context of the sentence (e.g., “peanut butter sandbox” vs. “peanut butter sandwich”) are counted as spelling errors.
- Capitalization and punctuation are not considered to be errors.

Composition Rate

- Calculated by dividing the total number of words in students’ writing by the total minutes of composition time.

Syntactic Maturity
One main clause and all subordinating clauses Ex.

I like the movie we saw about Dick the white whale the captain said if you can kill the white whale Moby Dick I will give this gold to the one that can do it and it is worth sixteen dollars they tried and tried but while they were trying they killed a whale and used the oil for the lamps they almost caught the white whale.

1. I like the movie / we saw about Moby Dick, the white whale.

2. The captain said/ if you can kill the white whale, Moby Dick, / I will give this gold to the one / that can do it.

3. And it is worth sixteen dollars.

4. They tried and tried.

5.But / while they were trying / they killed a whale and used the oil for the lamps.

6. They almost caught the white whale.

Each of the numbered sections is a T-unit.