Effects of word prediction and text-to-speech on the writing skills of students with learning disabilities

A. Patricia M. Barbetta1, and Monica Silio2

1 Office of Graduate Studies, Florida International University, 11200 SW 8th Street, ZEB 310, Miami, Florida, USA, barbetta@fiu.edu
2 Miami-Dade County Public Schools, Miami, FL, USA

This study investigated the effects of word prediction and text-to-speech on the writing skills of 6, fifth-grade boys with specific learning disabilities (SLD). A multiple baseline design across subjects was used to explore the efficacy of word prediction and text-to-speech alone and in combination on four dependent variables: writing fluency, syntax, spelling accuracy, and overall organization. Participants were equally divided into Cohorts A and B, and two separate but related studies were conducted. Throughout all phases of the study, participants wrote compositions for 15-minute sessions. During baseline, participants used word processing only. During the assistive technology intervention condition, Cohort A participants used word prediction followed by word prediction with text-to-speech. Concurrently, Cohort B participants used text-to-speech followed by text-to-speech with word prediction. The results of this study indicate that word prediction alone or in combination with text-to-speech has a positive effect on the writing skills of students with SLD. Overall, participants in Cohorts A and B wrote more words, more T-units, and spelled more words correctly. Additionally, the quality of writing improved as measured by holistic rubric scores. When participants in Cohort B used text-to-speech alone, with the exception of spelling accuracy, inconsequential results were observed on all dependent variables.

Keywords word prediction; text-to-speech; writing; learning disabilities

1. Introduction

The process of depicting ideas into written form can be a demanding task for students, particularly for students with specific learning disabilities [1]. Although these students are of average cognitive abilities, they often exhibit processing deficits that negatively impact their writing. These students often ineffectively concentrate their efforts on transcription skills, such as handwriting and spelling, and limit their word usage to words they are able to spell [2]. Furthermore, they tend to ignore the writing process, using preceding text to generate subsequent text, with little regard to organization or intended audience [3]. In addition, the continuous toggle from thinking about what to write to the mechanical demands of writing often causes students with SLD to overlook and omit important information needed to convey the intended message and expand on ideas [4]. As a result, frequently the writing of these students is quantitatively and qualitatively inferior to those of their typically achieving peers [5]. Meeting these writing challenges has become especially problematic given the increase in the number of students with SLD included in the general education curriculum [6, 7].

A variety of compensatory and/or remedial instructional approaches are being used to support the writing needs of students with SLD (e.g., mnemonics, graphic organizers, self-regulation strategies). In recent years, advances in the field of technology have triggered a variety of computer-related assistive technology solutions for compensating the writing challenges of students with SLD [8]. These tools are commercially available and minimally intrusive and include technologies such as word processing, spell checkers, speech recognition, text-to-speech, and word prediction technologies [8]. These assistive technology tools do not remediate or provide writing instruction, but rather they compensate low-level cognitive processes, such as spelling and keyboarding, thereby possibly allowing students with SLD to concentrate on higher order cognitive processes of synthesizing ideas [8].

Two computer-related assistive technology tools are becoming more readily available for use in the classroom: word prediction and text-to-speech. Word prediction provides a list of correctly spelled words related to the characters typed. The student selects the desired word from the list and then it is automatically inserted into the text. The text-to-speech tool uses a computerized voice to convert words from a written document into audible speech. This technology “reads” aloud electronic text and highlights the words as they are being read. It has been speculated that these tools may help students with SLD compensate for the mechanical demands of writing and allow them to concentrate more effort on content [9, 10]. The research on the use of word prediction is limited to a handful of studies with the most current research conducted with students with physical impairments [e.g., 11, 12]. The research on the effectiveness of word prediction and text-to-speech combined on the writing skills of students with SLD is even more limited and particularly dated. This study investigated the effects of word prediction with text-to-speech on the writing abilities of students with SLD and how well participants maintain the skills acquired. More specifically, this study investigated that with writing time held
constant, would students with SLD under (a) word processing, (b) word processing with word prediction, (c) word processing with text-to-speech, or (c) word processing with word prediction and text-to-speech combined: (1) perform more effectively in narrative composition writing as defined by writing fluency, syntax, and spelling accuracy?; (2) improve their overall organization of narrative composition writing?; and (3) maintain skills in narrative composition writing and organization on maintenance tests given at 2-, 4-, and 6-weeks after writing ended?

2. Method

Participants were 6, fifth-grade students who were enrolled in an urban public elementary school. Each participant was a Hispanic-American student identified as SLD, who earned a score ranging from 1.5 to 3.5 on the Florida Compressive Assessment Test (FCAT) Writing+. The FCAT Writing+ is a statewide assessment that measures student knowledge and understanding of writing with a scoring range between 0 (unscoreable) and 6.0 (highest possible score). Their scores on the Woodcock-Johnson Test of Achievement ranged from: (a) 1.9 to 6.1 on letter word identification, (b) 2.0 to 4.4 on spelling, (c) 1.8 to 4.6 on writing fluency, (d) 1.7 to 4.2 on passage comprehension, and (e) 1.5 to 4.3 on writing samples. Prior to beginning the study, the researcher, two special education, and one general education teacher selected narrative writing prompts for the study. The writing prompts were typed onto small sentence strips and randomly assigned to study conditions. The study software, Microsoft Word and WordQ™ [13] were installed on the participant’s computers (Six Dell Optiplex 755, 2.33 GHz personal computers). WordQ™ is a commercially available program that integrates word prediction and text-to-speech assistive technologies into one software package and that can be used with many existing word processing programs. Finally, independent raters were trained to collect treatment fidelity and interrater reliability data. Once the study began, it was conducted five days a week at the end of the school day in the computer lab of a large urban, public elementary school. During the study, the participants used the same computers everyday with headphones on and a vacant seat between them. During the writing sessions, the researcher walked around the room monitoring participant progress. The independent observer, when present, also walked around the room. At the end of each writing session, participants’ narrative writing samples were transferred from their computers to the researcher’s flash drive for collection and analysis on four writing elements. They included: (a) writing fluency (words read per minute, wpm), (b) syntax (number of T-units), (c) spelling accuracy (words spelled correctly, wsc), and (d) overall organization as measured by a holistic scoring method. A multiple baseline design across subjects was used in two separate but related studies. The 6 participants were divided into two equal groups, referred to as Cohort A and Cohort B. Both cohorts began the baseline condition concurrently. During baseline, participants wrote for 15 minutes to randomly-assigned narrative writing prompts using only Microsoft Office Word with its standard features. Once the researcher determined that an individual participant was to move to the intervention condition, a private, 30 minute, individualized training session was provided on the appropriate component of the WordQ™ application. The intervention conditions included the assistive technology tools word prediction and text-to-speech alone and in combinations. Cohort A’s intervention condition began with the implementation of word prediction alone as the independent variable using WordQ™ with Microsoft Office Word. After 12 to 14 sessions, training on using text-to-speech was provided and then it was used with word prediction during phase two of the intervention. Cohort B’s intervention condition began with the implementation of text-to-speech alone with WordQ™ and Microsoft Office Word. After 12-14 sessions, training on how to use the word prediction feature of WordQ™ occurred. This feature was then added to the text-to-speech intervention. This study design allowed an investigation of the effects of these technologies alone and in combination. Trained observers collected treatment fidelity and interrater reliability measures on 32% of the sessions. Procedures were followed with 100% accuracy on all writing sessions observed. The mean interrater reliability for writing fluency, spelling accuracy and overall organization was 99.7%, 91.3%, and 86.6%, respectively. Maintenance data were taken as 2-, 4-, and 6-week intervals following the completion of the study.

3. Results

This study examined the effects of word prediction and text-to-speech technologies in isolation and combined on the narrative writing skills of students with SLD. Participants were divided into two cohorts and assigned an intervention. During baseline, Cohort A’s mean writing fluency was 8.2 wpm, with a range of 5.0–10.1. When word prediction software was introduced, Cohort A’s mean writing fluency increased to 11.3 wpm, with a range of 11.1–11.8. When text-to-speech was added to word prediction, Cohort A’s mean writing fluency increased to 14.0 wpm, with a range of 12.9–15.4. Overall, Cohort A’s writing fluency was highest in word prediction with text-to-speech phase with an increase of 5.8 wpm over baseline. During baseline, Cohort B’s mean writing fluency was 3.0 wpm, with a range of 1.7–5.1. When text-to-speech software was introduced, Cohort B’s mean
writing fluency decreased to 2.6 wpm, with a range of 1.2–4.5. When word prediction was added to text-to-speech, Cohort B’s mean writing fluency increased to 4.1 wpm with a range of 2.6–5.4. Overall, Cohort B’s writing fluency was highest in text-to-speech with word prediction phase, with an increase of 1.1 wpm over baseline.

Cohort A’s mean number of T-units written during baseline was 10.9, with a range of 8.8–14.5. When word prediction software was introduced, Cohort A’s mean number of T-units written increased to 14.5, with a range of 12.6–16.4. When text-to-speech was added to word prediction, Cohort A’s mean number of T-units written increased to 17.7, with a range of 14.1–21.2. Overall, Cohort A’s mean number of T-units written was highest in word prediction with text-to-speech phase, with an increase of 6.8 T-units over baseline. When measuring the mean number of T-units, Cohort B’s baseline performance was 4.0, with a range of 1.7–7.4. When text-to-speech software was introduced, Cohort B’s mean number of T-units written decreased to 3.9, with a range of 1.8–7.4. When word prediction was added to text-to-speech, Cohort B’s mean number of T-units written increased to 5.6, with a range of 3.6–8.9. Overall, Cohort B’s mean number of T-units written was highest in the text-to-speech with word prediction phase, with an increase of 1.6 T-units over baseline. During baseline Cohort A’s mean spelling accuracy was 94.2% words spelled correctly (wsc), with a range of 83.3–97.1%. When word prediction software was introduced, Cohort A’s mean spelling accuracy increased to 97.5% wsc, with a range of 99.3–99.9. When text-to-speech was added to word prediction, Cohort A’s mean spelling accuracy increased to 99.7% wsc, with a range of 93.3–100%. Overall, Cohort A’s mean spelling accuracy was highest in the word prediction with text-to-speech phase, with an increase of 5.5% wsc over baseline. Cohort B’s baseline mean spelling accuracy was 97.2% wsc, with a range of 95.7–98.2. When the word prediction software was introduced, Cohort B’s mean spelling accuracy increased to 99.1% wsc, with a range of 98.6–100. When word prediction was added to text-to-speech, Cohort B’s mean spelling accuracy increased to 99.8% wsc, with a range of 99.6–100. Overall, Cohort B’s mean spelling accuracy was highest in the text-to-speech with word prediction phase, with an increase of 2.6% wsc over baseline. During baseline, Cohort A’s mean holistic rubric score was 3.2, with a range of 2.0–4.6. When word prediction software was introduced, Cohort A’s mean holistic rubric score increased to 4.1, with a range of 3.7–5.5. When text-to-speech was added to word prediction, Cohort A’s mean holistic rubric score increased to 4.7, with a range of 3.7–5.7. Overall, Cohort A’s mean holistic rubric score was highest in the word prediction with text-to-speech phase, with an increase of 1.5 over baseline. With respect to mean holistic rubric score, Cohort B’s score was 1.7, with a range of 0.2–3.4. When text-to-speech software was introduced, Cohort B’s mean holistic rubric score decreased to 1.6, with a range of 0.5–3.3. When word prediction was added to text-to-speech, Cohort B’s mean holistic rubric score increased to 2.6, with a range of 1.7–4.4. Overall, Cohort B’s mean holistic rubric score was highest in the text-to-speech with word prediction phase, with an increase of 0.9 over baseline.

4. Discussion

Although outcomes varied for individual participants, overall the results of this study demonstrate that word prediction alone and combined with text-to-speech had a positive impact on participant writing as measured by the dependent variables. The use of text-to-speech alone resulted in little or no impact. With few exceptions, participants maintained a high percentage of composition skills developed. Overall, the results of this study lend further support to the limited research, which demonstrated that word prediction alone and combined with text-to-speech have a positive impact on the writing of students with SLD [9, 14, 15].

With respect to writing fluency, participants in both cohorts wrote more words during the combined use of word prediction and text-to-speech. The impact of the interventions, however, varied. All three participants in Cohort A improved their writing fluency when the word prediction alone application was activated. There did, however, continue to be high variability of performance during word prediction as was observed in baseline. Perhaps, this was due in part to differences in the narrative topic assigned each day. When the text-to-speech application was added to the word prediction, Cohort A continued to make gains in writing fluency and overall, there was more stability in performance. On the other hand, writing fluency for Cohort B participants maintained or fell slightly when text-to-speech was introduced as the first intervention, but their performances improved over baseline levels when word-prediction was added to the text-to-speech application. Maintenance of writing fluency was measured at 2-, 4-, and 6-weeks after the intervention ended. All 6 participants maintained a high percentage of their writing fluency performance. These results suggest that for students with SLD, word prediction alone or in combination with text-to-speech will increase writing fluency. The results of this study, however, do not suggest the use of text-to-speech alone should increase writing fluency. Furthermore, no previous research was found that looked at the effects of text-to-speech alone on writing fluency which supports previous work [9]. Visual inspection of the T-unit data showed that the use of word prediction alone (with Cohort A) resulted in an overall increase in the number of T-units. However, the use of text-to-speech alone (with Cohort B) did not increase the overall number of T-units. Further, the results indicate that the
participants in both cohorts wrote more T-units during the combined use of word prediction and text-to-speech. Subsequently, this study demonstrated that word prediction alone and in combination with text-to-speech will improve the syntactic maturity of students with SLD. It is possible that these results were due in part to participants’ reduced mechanical demands while using word prediction alone or in combination. That is, participants may have generated more T-units because word prediction and word prediction with text-to-speech enabled them to concentrate their efforts on the intended message (content) rather than writing mechanics. However, text-to-speech alone had no positive impact. Prior to this study, no other research studies were found that measured the effects of word prediction or text-to-speech on syntactic maturity. Subsequently, the results of this study should be viewed as preliminary.

The results indicate that participants in both cohorts spelled more words correctly than in baseline with the activation of both word prediction and text-to-speech alone. These spelling improvements over baseline levels were similar with the combined use of word prediction and text-to-speech. When the use of word prediction and text-to-speech was combined for both Cohorts, the variability of spelling accuracy performance was reduced. Overall, participants from both cohorts maintained their spelling accuracy, with the exception of one participant who misspelled one word on the Week 6 maintenance probe. The results of this study contradict the results of a previous study [10] in which word prediction did not improve the spelling accuracy of students with SLD. The authors of that study suggested that the lack of spelling improvement may have been a result of limited word prediction capabilities of the software. The WordQ™ software used in the present study, however, compensated for invented spelling which could account for the differences in the results between the two studies. Participants in both cohorts received higher holistic rubric scores during the combined use of word prediction and text-to-speech, demonstrating improved overall composition organization. Word prediction alone (Cohort A) and in combination with text-to-speech (Cohorts A & B) resulted in improved holistic scores, whereas text-to-speech alone did not result in improved scores. Participants in both cohorts maintained their holistic rubric scores when using text-to-speech with word prediction. The fact that students improved their holistic rubric scores when using word prediction alone and in combination with text-to-speech lends support to the use of this technology as a classroom accommodation for students with SLD.

This study extends the literature on the effects of writing with word prediction and text-to-speech. Prior to this study, only five studies were found that included students with SLD [9, 10, 14, 15]. Additionally, this limited research was conducted approximately 10 years prior to this study, therefore possibly rendering it of limited value, given the advances in the assistive technologies investigated. This study provided an updated analysis with current, more sophisticated software and with participants who likely had more computer familiarity, knowledge, and skills. This study also expands the literature in that it examined the effects of word prediction and text-to-speech alone and in combination and suggested that word prediction alone has a greater impact on writing than text-to-speech alone. Previous research only explored the effects of the combined use of the two software applications.

The results of this study have implications for classroom practice. Teachers of students with SLD should consider word prediction or word prediction with text-to-speech as a writing support to facilitate the production of a narrative first draft. However, the use of text-to-speech alone should be used more cautiously as its effectiveness has not been established. The two areas where word prediction and word prediction with text-to-speech seemed to be most effective were for writing fluency and overall organization. This software should be considered for students who struggle to produce significant text. Additionally, the text-to-speech application helps students with prediction choices as it reads the contents of the word prediction list. Finally, when using word prediction with text-to-speech application in the classroom, teachers should have students use headphones to minimize distractions.

There are several limitations and suggestions for further to this study. First, the demographic characteristics of the participants who took part in this study were restricted to fifth-grade, Hispanic-American boys, who were labeled as having an SLD. Participants with other demographic characteristics should be considered in future research such as girls, students differing in abilities and disabilities, students at different grade levels, and students with different ethnic and cultural backgrounds. Another limitation lies in the software application and its features. The software used in this study, WordQ™, is only one of several word prediction and text-to-speech software packages currently available. The results of this study cannot be generalized to other software that may differ in functionality and complexity. The use of WordQ™ with features not used in this study. The present study was limited to narrative writing, which is a story told from the author’s perspective and relies on personal experiences. Future research should investigate the effects of these technologies on different writing genres. An additional limitation was that participants in this study did not use the writing process with its progression of recursive phases (planning, text generation, and revision) to write their narrative compositions. Instead, they wrote their response to each narrative writing prompt, which is the text generation phase, during one writing session. Future research should investigate the effects of these technologies if used at different stages of the writing process. In closing, this study suggests that word prediction alone and in combination with text-to-speech has a positive impact on the writing of students with SLD. Although text-to-
speech only produced notable effects in spelling accuracy when used in isolation, it did enhance writing when used in combination with word prediction. Ongoing research is needed to determine the effectiveness of these assistive technologies with students with significant writing problems, such as those with SLD and other learning challenges and varying writing abilities.

References


