Using Word Prediction Software to Increase Typing Fluency
with Students with Physical Disabilities

Jennifer Tumlin
Kathryn Wolff Heller
Georgia State University
Having the ability to write accurately and effectively is a necessary skill at school and in daily activities. Students with physical disabilities often have difficulty with the mechanics of writing, including speed and spelling issues. To help increase writing efficiency in these areas, students are often taught to use various forms of assistive technology, such as word prediction software. Although word prediction software has been successfully used with other populations of students to increase typing speed and decrease spelling errors, systematic studies have not been performed examining the effectiveness of this approach with students who have physical disabilities that affect hand use.

The physical act of writing can be difficult for students with physical disabilities. For some students with physical disabilities, handwriting may not be an option due to limitations in motor control, difficulty forming letters, illegible writing, or slow speed. Typing is often a more feasible option since it eliminates legibility problems and is considered faster than handwriting for skilled typists who do not have disabilities (MacArthur, 1996, 1999a). However, students with physical disabilities can find typing to be laborious due to limitations in motor control, slow typing speed, and unfamiliarity with the standard keyboard arrangement (Lewis, Graves, Ashton, & Kieley, 1998).

To make typing a more feasible option, some students with physical disabilities may need to use a different means of accessing the computer rather than a standard keyboard. In these instances, before students with disabilities can access the computer, it is imperative that a reliable method for inputting information is in place (Mebler, Hadadian, & Ulman, 1999). There are several different types of assistive technology that may be used to assist students with motor problems in gaining computer access. In some instances, alternative keyboards may be necessary
for students to use instead of the standard QWERTY keyboard (Logwood & Hadley, 1996). According to Merbler et al. (1999) there are four types of alternative keyboards: (a) programmable keyboards, (b) chording keyboards, (c) miniature keyboards, and (d) on-screen keyboards. Programmable keyboards allow for customization of the keyboard, such as varying the repeat rate, keyboard sensitivity, and keyboard layout. Chording keyboards typically have fewer keys and work by the user pressing key combinations. Miniature keyboards are smaller than standard keyboards, requiring less range of motion. Finally, on-screen keyboards appear on the computer screen and can be accessed by using a mouse, joystick, trackball, touch screen, switch (with scanning), touch screen, or other input device. Due to the wide variety of alternate keyboards, these keyboards are often a viable alternative to standard keyboards for many individuals with physical disabilities. However, students with physical disabilities who are using appropriately selected alternative keyboards may continue to type at a slow rate.

In addition to slow typing rates, students with physical disabilities may also have spelling errors. Spelling errors may occur due to mechanical writing errors resulting from motor control issues. This can occur whether students are using a standard keyboard or an appropriate alternate input device that has been selected for them. It is important to assess whether spelling errors are due to the inability to spell a word or due to erratic motor patterns and keyboarding mistakes.

Outside of the mechanics of writing, the actual ability to spell can also be problematic for students with physical disabilities. Phonological awareness is said to predict spelling ability, and Sandberg (1998) indicated that this is true for non-speaking students with cerebral palsy as well. Sandberg (2001) also reported that there is often a discrepancy between intelligence and literacy skills of students with cerebral palsy and speech impairments. Reasons for this can include motor problems, difficulty with expressive and receptive communication, memory problems, and
phonological skills. Results from a three-year longitudinal study, showed students still far below their peers in spelling, but they were attempting to spell more words. However, children with severe speech impairments and physical disabilities tended to make omission errors, a different type of spelling error than their peers made (Sandberg, 2001).

One solution that may address both the slow speed of accessing a standard or alternate keyboard and spelling issues is word prediction software. Most word prediction programs can be used with any word processor, with the student typing in a window separate from the word processor. As the student types, word prediction software begins predicting the word the student is trying to type and provides a list from which a correct word can be selected. The student can select the goal word by either clicking on it with the mouse or by typing the number of the corresponding word. If the correct word is not in the list, the student continues to type and the list of predicted words changes accordingly. When the student types a period or presses enter, the sentence is transferred from the word prediction software to the word processor (MacArthur, 1999a; 1999b). Lewis et al. (1998) stated that the words predicted are typically based on “word frequencies and grammatical algorithms” (p. 97) and that advanced programs can actually learn new words that the user inputs.

In relationship to physical disabilities, MacArthur (1999a) stated that “word prediction software was originally developed for individuals with physical disabilities to reduce the number of keystrokes required to type words” (p. 178). Word prediction software can be beneficial for students with fine motor problems who are poor typists, who have difficulty with handwriting, or who need help with spelling tasks. MacArthur (2000) suggested that word prediction could be an option for students who could not read their own handwriting or for students whose spelling was so poor that a spell checker could not offer usable suggestions. Merbler et al. (1999) suggested
that word prediction software was suitable for any student who had keyboarding difficulties because it reduced the number of keystrokes, thereby allowing the student to click on a whole word before the word had been completely typed.

Benefits to word prediction include helping with spelling problems, especially students whose spelling is too unrecognizable for spell checkers (MacArthur 1998a, 1999a). MacArthur (1998a, 1998b) stated that word prediction could support correct spelling as well as expand the use of vocabulary. Limitations, however, included the user needing to type the initial letter of the word correctly (MacArthur, 1998a). Also, it should be noted that if the word prediction program incorrectly predicts the student’s intended word by not including the student’s target word in the group of words it displays, it may take longer and require more keystrokes to finally have the desired word displayed.

Research examined the use of word prediction for individuals with learning disabilities. For example, Lewis et al. (1998) assessed students’ writing and found that students with learning disabilities could handwrite the fastest, with word prediction next, and typing in a word processor last. They reported that teachers believed that for more advanced typists, word prediction software slowed down their typing rate. Lewis et. al. (1998) indicated that slower typing speeds with word prediction could be due to a lack of practice and keyboard unfamiliarity. They surmised that if students had more typing practice, the results might have been different. This conclusion does not necessarily carry over to physical disabilities, however, because these students might never be able to increase their rate of typing due to motor coordination problems unless there are compensatory devices in place.

In another study (Golden, 2001) with students with learning disabilities using word prediction software, the keyboarding rate of one student with learning disabilities decreased
when using word prediction. This student had the highest words per minute rate when copying from text and had a good knowledge of character placement on the standard keyboard. In this instance, it was thought that the time it took to search the word prediction list could have interrupted this faster typist and resulted in slower typing speed.

As these studies suggest, word prediction performance can rely on several factors. Student characteristics such as the amount of time it takes to press a key and the amount of time it takes for a student to search the word prediction list can influence writing rate. Also, word prediction system characteristics such as searches per character and keystroke savings can also influence word prediction performance (Koester & Levine, 1998; Koester & Levine, 1997). For students with physical disabilities, the keypress time is the factor that is most divergent.

Although the use of word prediction holds promise for students with physical disabilities in increasing writing efficiency, further research is needed. The purpose of this study was to examine the use of word prediction software to increase typing speed and decrease spelling errors for students who have physical disabilities that affect hand use. Student perceptions regarding the effectiveness of word prediction was examined as well as their typing rates and spelling accuracy.

**Method**

**Participants and Setting**

Four students with physical disabilities were selected for this study. Criteria for participation included: (a) having a physical disability with fine motor problems, (b) meeting the Georgia requirements for orthopedic impairments (i.e., students with physical disabilities having mild intellectual disabilities or above), (c) receiving services through an orthopedic impairments special education program, (d) being high school age, (e) having utilized word processing for a
minimum of two years, (f) having a below average handwriting rate, typing rate, and/or making spelling errors on over 5% of their work (either due to motoric or learning issues), (g) having had no formal instruction of the use of word prediction software, and (h) having had prior experience with accessing a computer (either with standard keyboard or alternate access devices).

The four students selected for this study had either cerebral palsy or brain injury, the severity of which affected the fine motor coordination of their hands. These specific disabilities were targeted since individuals with these types of disabilities can have difficulty with typing speed and the mechanics of spelling. Also, cerebral palsy and brain injury can both have similar motor patterns including difficulties with manipulation, fine and gross motor coordination, motor planning, finger strength, eye-hand coordination, and visual scanning skills (Lueck, Dote-Kwan, Senge, & Clarke, 2001).

Van was a 21-year-old student who had traumatic brain injury and severe dysarthric speech. He needed to use a wheelchair for independent mobility, although he could walk using a walker with support. He had poor gross and fine motor manipulation due to tremors that resulted in an inability to write with a pencil. He was left-handed prior to his accident, but preferred using right hand for most tasks after the accident. He had double vision and was unable to auditorily process sound due to his brain injury. However, he was able to see a font on the computer of 22 point or larger size. All information was presented visually due to his auditory processing impairment. Prior to his accident, Van had been given formal keyboarding instruction through a high school keyboarding class that provided him with basic word processing skills. Due to the severity of his physical impairment he used a programmable alternative keyboard (IntelliKeys) to type with the repeat rate adjusted due to problems of repeatedly hitting keys.
However, his typing was slow so he completed all of his assignments by dictating to a scribe. Of the four students, he had the slowest typing speed.

Sam was a 16-year-old who had spastic, quadriplegic cerebral palsy and dysarthric speech. He used a power wheelchair for independent mobility and he could pick objects off his wheelchair tray and release them, but was unable to manipulate objects well. He was not able to write using a pencil. Despite the severity of his physical impairment, Sam was able to access a standard keyboard on a laptop computer, and he had basic word processing skills. However, he completed most of his work by dictating to a scribe because his typing rate was so slow. He often needed to reset or reposition his arm to achieve the desired motor pattern.

Nick was 18 years old, had athetoid and ataxic cerebral palsy, and had moderate dysarthric speech. He was able to walk, although unsteadily. He had uncontrolled movement in his hands and arms and often needed to stabilize one arm with the other to execute certain movements. He could pick up objects and manipulate them, although his fine motor control was poor. He could write approximately two words per minute using a pencil, but his handwriting was illegible. He was able to type much faster using a laptop computer which he would use two hand to access. For assignments he would use either a laptop computer with word processing or dictate to a scribe.

Frank was 17 years old and had a brain injury due to a brain stem aneurysm. He used a wheelchair for independent mobility, but could use crutches with stand-by assistance. He also had mild dysarthric speech, memory problems, as well as some vision and hearing loss on the left side. Although he was able to manipulate small objects, hand coordination issues resulted in
slow handwriting that was often laborious and inefficient. He completed assignments by handwriting and using basic word processing on the computer. When given a choice, he would choose not to use technology. Frank took a formal keyboarding class after his aneurysm and was able to access the computer with both hands. However, during the class, Frank’s keyboarding goals were modified and decreased due to his fine motor difficulties. Frank had the fastest typing speed of the four students.

All students were instructed in the orthopedic impairments (OI) classroom by the OI teacher with standard materials (e.g., laptop, alternative keyboard). Observation during word processing tasks in the classroom indicated that all students were able to use word processing to type. Since all students were most familiar with Microsoft Word, it was selected as the word processing software.

**Word Prediction Software**

Co:Writer was selected as the word prediction software to be used in the study due to its ease of use and having the desired features (e.g., highly visible word choices, easy selection of target word). This commercial word prediction program can be used with virtually any word processor. The user types in a window separate from the word processor. As the student types, Co:Writer begins predicting the word the student is trying to type and provides a list from which the correct word can be selected. The user can select the correct word by either clicking on it with the mouse or by typing the number of the corresponding word. If the correct word is not in the list, the user continues to type and the list of predicted words changes accordingly. When the user types a period or presses enter, the sentence is transferred from Co:Writer to the word processor.
During this study, the Co:Writer program preference was set to the intermediate dictionary, which consists of 12,000 words. The program was set to display five word choices at a time. The speech synthesis feature was turned off for all students because it was hypothesized that the speech synthesis would slow the text entry process (Lewis et. al., 1998).

**Procedure**

*Determining baseline.* During participant selection, each student’s baseline typing rate and percent of spelling errors were assessed to determine if participants were candidates for the study. This occurred by providing five sessions in which the participants typed using only word processing. Typing rate was determined by counting four characters as a word and was reported as words per minute (MacArthur, 1998b). Spelling errors were calculated and reported as the percent of words spelled incorrectly. Unlike the typing rate, the words were viewed as individual words, not as a set number of characters. Percent of spelling was calculated by dividing number of spelling errors by total words typed. Determination of baseline typing rate and percent of spelling errors occurred across five sessions. Students were timed for two minutes for each session.

Although three-minute sessions are often used in the learning disabilities literature (Lewis et. al., 1998), a different criterion for students with physical disabilities was needed. Students with severe physical impairments have motor planning and fatigue issues that interfere with continuous typing. Pauses or breaks interfere with calculating words per minute and this may vary greatly from day to day due to their physical disability and other issues. Therefore, two minutes was selected to decrease pauses and fatigue.

*Co-Writer instruction.* Prior to the study, the students received individual instruction on the use of Co:Writer from the classroom teacher during their resource technology class. The
teacher explained and modeled the features of the software and then provided guided and independent practice. Students were instructed to type a word letter-by-letter and look at the word list after each letter typed (Koester & Levine, 1998). They were instructed to select the correct word by typing the corresponding number. Instruction in the use of Co:Writer and its features continued for each student until he was able to achieve 100% accuracy on the checklist as demonstrated through observation. Items on the checklist included opening Co:Writer with Microsoft Word, typing, scanning the list after each typed letter, selecting the word from the list, sending text to Microsoft Word, and returning to the Co:Writer interface. Once students were observed completing all items on the checklist with 100% accuracy, intervention began.

Writing sessions. The writing sessions consisted of the students being instructed to type a short paragraph about daily events. This type of passage was selected so the students would not have to concern themselves with writing processes and could concentrate on typing and spelling. Students were provided with a writing prompt (e.g., what did you have for dinner?). The teacher then discussed the writing prompt with the students and had them tell her what they were going to type. Rehearsal was important to eliminate pauses and to ensure that there was a continuous flow and the students did not have to stop to think about what they were writing. The teacher then timed the student typing for two minutes.

During writing sessions, an observer stood behind the student to ensure that word prediction was being used. When the student completed typing, he was directed to print a copy and the teacher then analyzed the permanent product for words per minute and spelling errors. Words per minute and spelling errors were calculated as the same way as determined for baseline word per minute rate and percent of spelling errors.
Design

In this study, the dependent variables were typing rate and percentage of spelling errors. The independent variable was the use of word prediction software. A reversal design (Baer, Wolf, & Risley, 1968) was selected for this study in order to display a functional relationship between the use of word prediction on spelling errors and typing rate. The five-session pretest that established their typing rate and spelling errors was used as baseline. During this time, the participants used only a word processor to write.

After baseline was complete, the first intervention phase was started. During the intervention phase, the students used the Co:Writer word prediction program with the word processing program. Typing rates and spelling errors were calculated for each session. Due to the variability and unpredictability of motor skills of students with physical disabilities, this phase (and all phases) were conducted for five sessions.

A return to baseline phase occurred next, during which the students wrote using only the word processor. This continued for five sessions and was followed by a second intervention phase. In the second intervention phase, the students wrote using word prediction.

It was anticipated that some students would continue using word prediction software after the conclusion of this study. It was decided that a two-session probe would be taken with and without word prediction one year after the completion of the study for students who continued to use word prediction software. This probe would be an indication of the consistency of results over time. In addition, a five-minute probe would be taken at this time to compare the differences between two minute and five minute typing rate for students whose physical impairment may affect writing for longer periods of time.
Reliability & Social Validity

Inter-observer reliability (IOR) was calculated in 20% of the sessions, occurring once per phase, and the classroom paraprofessional served as the second observer. Both observers calculated rate of typing in words per minute and percentage of spelling errors. IOR was 100%. Treatment integrity was provided through following a checklist of daily events.

Social validity was also assessed through a pre-treatment and post-treatment questionnaire with the students. The questionnaire consisted of eight questions that asked questions assessing their perception of Co:Writer (i.e., it will help me type faster; I’ll like using it; I’ll use it in other classes; I’ll use it outside of high school). It asked two value questions regarding importance of typing faster and spelling words correctly. It asked if they would recommend it to other people. The posttest asked the same questions based on their experience having used Co:Writer during the study. The students responded to questionnaire items using a 3-point Likert Scale (with 3 being agree and 1 being disagree).

Results

Words Per Minute

One of the purposes of this study was to determine whether word prediction software would increase typing rate of students with physical disabilities. The number of words typed per minute with and without word prediction software was calculated for each student and is displayed in Figure 1 and 2. The use of word prediction software on typing rate varied across the four students.

Van. Van’s results, indicated in Figure 1, showed a baseline mean of words typed per minute of 2.9, with a range of 2.4 – 3.4. With the introduction of word prediction software in
intervention 1, mean words per minute typed rose to 3.4, with a range of 2.1 – 4.4. In Baseline 2, Van’s mean dropped back to 2.5 words per minute with a range of 2.3 – 2.6. With the reintroduction of Intervention 2, mean words per minute rose to 3.8 with a range of 3.0 – 5.4.

Percent of overlap was calculated and indicated a 40% overlap between Baseline 1 and Intervention 1; 100% between Intervention 1 and Baseline 2; and 0% between Baseline 2 and Intervention 2, indicating great variability and similarity between some phases. Because percent of overlap was so great between the phases, a weak relationship existed between treatment and outcome (Tawney & Gast, 1984).

*Sam.* Figure 1 results indicate that word prediction provided an increase in typing rate for Sam. Baseline 1 indicated a mean of 4.7 with a range of 3.9 – 5.5. Intervention 1 results display a mean of 6.8 with a range of 5.3 – 7.8. Returning to Baseline 2, Sam’s mean words per minute was 5.2 with a variable range of 3.9 – 7.6. With the reintroduction of word prediction software in Intervention 2, his mean increased to 6.4 with a range of 3.6 – 9.0 words per minute. Sam showed an increase in words typed per minute when using word prediction software in both intervention phases. Percent of overlap was calculated and indicated a 20% overlap between Baseline 1 and Intervention 1; 40% between Intervention 1 and Baseline 2; and 40% between Baseline 2 and Intervention 2, indicating a weak relationship between intervention and outcome (Tawney & Gast, 1984).

*Nick.* Nick’s words per minute results are shown in Figure 2. In baseline 1, Nick averaged 10.9 words per minute, with a range of 13.8 – 15.4. When word prediction software was introduced in Intervention 1, his mean increased to 13.5 with a highly variable range of 11.9 – 17.9. When returning to baseline, mean words per minute performance increased to 12.8 with a range of 11.8 – 14.3. Intervention 2 indicated a decrease in words per minute, with a mean of
11.2 and a range of 10.0 – 14.3. Percent of overlap was calculated and showed a 40% overlap between Baseline 1 and Intervention 1; 80% between Intervention 1 and Baseline 2; and 20% between Baseline 2 and Intervention 2. A functional relationship does not exist, indicating that a clear effect for improvement in typing rate using word prediction software was not present for Nick.

*Frank.* The results for Frank are shown in Figure 2. In Baseline 1, Frank’s mean words per minute was 14.6 with a range of 13.8 – 15.4. When word prediction software was introduced, his mean words per minute dropped to 9.8 with a range of 7.9 – 12.3. Going back to baseline, his mean words per minute increased to 14.0 with a range of 12.9 – 14.6. When word prediction software was reintroduced, the mean words per minute fell to 10.4 with a range of 7.3 – 12.9. Percent of overlap was calculated and indicated a 0% overlap across all phases, indicating a clear impact of treatment on behavior (Tawney & Gast, 1984). These results indicated that Frank’s overall typing rate was faster without word prediction software. A functional relationship existed, in that there was clear difference in levels between baseline and treatment phases.

**Probe Data**

One year after the study, Sam and Nick continued using word prediction software at school. As seen in Table 2, probe data on two minute sessions for Sam and Nick indicated higher word per minute rate with word prediction than without. During the two-minute sessions, Sam’s mean rate without word prediction was 7.88 words per minute (range 7.50- 8.25), and with word prediction, he had a mean rate of 9.38 words per minute (range 9.13 - 9.63). Nick’s mean rate without word prediction was 12.06 words per minute (range 11.75 - 12.38) and with word prediction, he had a mean rate of 14.56 words per minute (range 13.50 - 15.63). Probe data taken on five-minute sessions indicated a lower word per minute rate than with two minute probes.
Spelling

Table 3 displays the percent of spelling errors for each participant. During Baseline 1, Van made an average of 8% spelling errors. When word prediction software was introduced, his spelling errors decreased to 0%. With the reintroduction of baseline, spelling errors rose to 5%. Intervention 2 yielded 0% errors. Sam’s results were similar. During Baseline 1, Sam made 6.2% spelling errors. With the introduction of word prediction, his spelling errors decreased to 0%. Returning to baseline, Sam made 10.9% errors. With the reintroduction of intervention, spelling errors fell to 3.3%.

Nick began Baseline 1 with 13.1% spelling errors. With introduction of word prediction, his spelling errors fell to 1.8%. During Baseline 2 however, Nick made 0 spelling errors. In Intervention 2, Nick made 1.1% spelling errors. Frank began Baseline 1 with 4.4% errors. During Intervention 1, spelling errors fell to 0%. During Baseline 2, spelling errors were .76% and during Intervention 2 1.1% errors.

In the case of Sam and Van, mean percentage of spelling errors was lower in both intervention phases than in both baseline phases. In the case of Frank and Nick, mean percentage of spelling errors was lower in Intervention 1 than in Baseline 1 but was slightly higher in Intervention 2 than Baseline 2.
Treatment Integrity & IOR

No changes were made to the original plan for the study. Each student was assigned a computer, and default settings were configured and maintained individually for each student throughout the study. A treatment integrity checklist was prepared and followed 100% of the time by the classroom teacher and paraprofessional throughout the study.

Inter-observer reliability (IOR) data were taken in 20% of the sessions. A classroom paraprofessional was trained to serve as the second observer and calculated words per minute and percent of typed spelling errors one time per phase across all students from permanent products. IOR was 100% across all phases and all students.

Social Validity

Prior to the study and immediately following the study, students were given social validity surveys. The surveys, displayed in Table 4, consisted of nine questions and used a three-point Likert Scale (with 3 being agree and 1 being disagree). Three out of four students indicated that they felt that Co:Writer helped them type faster, and two out of four indicated that they felt that Co:Writer helped them spell better. Three out of the four reported that they liked using Co:Writer and expected that they would prior to using it. None of the students expected to use it outside of the OI classroom and only one student planned on using it outside of school. The two students with the most severe physical disabilities (Van and Sam) responded that they felt less tired after using word prediction software.

Put Table 4 about here
Discussion

The purpose of this study was to determine if the use of word prediction software would increase the typing rate and decrease spelling errors of students with physical disabilities affecting hand use. Because some physical disabilities can severely limit typing speed and accuracy of pressing the correct letters, it is necessary to find ways to increase efficiency of output for these individuals. In this study, the results indicated that word prediction software had a small positive effect on overall typing rate and decreased spelling errors for two out of four students. For one student, the word prediction software program was found to negatively impact typing rate.

The two students (Van and Sam) who showed an improvement in words per minute when using word prediction software had the most severe physical disabilities of the four students. They also had the slowest typing speeds. Based on Van’s mean words-per-minute baseline of 2.9, it was calculated that he made an average of 11.6 keypresses (or keystrokes) per minute and an average of 5.2 seconds to make one keypress. Calculated the same way, Sam was similarly slow by taking an average of 3.2 seconds to make one keypress. This is much slower than the values found in Doester and Levine’s (1997) study in which it took approximately one second or less to make one keypress. These students’ severe physical disabilities were accompanied with more abnormal motor patterns that resulted in slower keypress times. In these two instances with students with severe physical disabilities, word prediction appeared to have increased typing speed while decreasing the number of keystrokes required to type words. This aligns with the original intent of the development of this type of technology for individuals with physical disabilities.
In this study, two other students did not show an improved typing speed while using word prediction. Nick showed no consistent change in words per minute using word prediction software while Frank’s word-per-minute rate decreased with word prediction software. Nick and Frank had less severe physical disabilities than the other two students in the study. Based on baseline typing rate, Nick took an average of 1.38 seconds to make one keystroke. Frank was the fastest typist in the study, taking 1.03 seconds to make one keystroke. With these students having the physical capability to access the keyboard faster, it is possible that it took about the same time or longer to scan the word prediction selections as type the whole word. This aligns with studies with students with learning disabilities indicating that more fluent typists may have a decrease in typing speed when using word prediction software (Golden, 2001; Lewis et. al., 1998).

Since there was a range of typing speeds among the four students with physical disabilities, questions arise if their typing speeds would improve with additional practice as suggested for students with learning disabilities (Lewis et al., 1998). For the two students who continued to use word prediction one year following the study, it is noted that Sam’s typing speed was faster with and without word prediction than in the original study and Nick’s typing speed was higher with word prediction than the original study. These data show some increases in typing speed with one year’s practice using word prediction, but the small amount of improvement tends to support that there are additional factors to consider with students with physical disabilities.

Fatigue, attention, keypress rate, and motor planning issues are additional factors that affect the performance of individuals with physical disabilities that must be carefully considered. Having to concentrate on motor planning can affect the student’s ability to type. When all energy
needed to complete a task is concentrated on the physical act of performing the task, the overall result can become inefficient and the student can become fatigued. This was observed when typing sessions were increased to five minutes during the follow-up probe sessions. During the five-minute probe sessions, the word-per-minute rate was lower for both Sam and Nick than during the two-minute probe sessions. During observation, it was noted that Sam and Nick had considerably more pauses during the five-minute sessions. The teacher felt that this was primarily from fatigue issues and having to readjust arm position due to abnormal motor patterns. This indicated that typing for longer periods of time may result in decreases in typing speed due to motoric and fatigue factors. However, despite the different session lengths, both Sam and Nick had similar results during the five-second probe sessions as with the two minute sessions in the reversal design. Sam had higher words per minute with word prediction and Nick showed no clear difference. Although Van, who had the most severe physical disability, could not be part of the one-year follow-up due to graduating, his teacher reported that he was physically incapable of typing for five minutes due to severe motor planning and fatigue issues. This indicates the importance of considering the impact of these additional factors on typing performance.

When examining the typing speed of these students, an important issue is raised regarding the effect of word prediction in functional classroom situations with students with severe motor planning issues and fatigue. Improvement in typing speed with word processing may be very minimal if increasing fatigue occurs when typing over the course of a typical classroom period or assignment. However, any increase in typing speed (and spelling accuracy) can be viewed as beneficial when students type so slowly. Further studies are needed to examine
the effect of fatigue and motor planning issues on word prediction use during a typical fifteen to twenty minute writing period in the classroom.

In the area of spelling, results indicated that the use of word prediction did produce lower rates of spelling errors in the case of Van and Sam. The improvement in spelling occurred with the two students with the most severe disabilities. Van made zero spelling errors during both intervention phases, demonstrating that the use of word prediction software worked effectively to eliminate spelling errors. Although Van made no spelling errors using word prediction, in session 18, he did select the wrong word on the word prediction list (parts instead of part). Having students carefully examine the list of words is important to teach. In Intervention 2, Sam misspelled one word. He was trying to type the word metal but began typing “ma” instead. In this case, he was not able to locate the correct word in the word prediction list and therefore typed the whole word incorrectly (as “matal”). At the time of the study, Co:Writer 4000, which has flexible spelling, was not available. It is anticipated that the use of word prediction programs with more flexible spelling rules may be of even greater benefit to poor spellers and may help to reduce spelling errors even further.

There are several limitations of the study that need to be considered. First, as with most single subject designs, this study used a small number of individuals. Further replications of this study needs to be conducted to determine the effects of word prediction across a greater number of students with physical disabilities that affect hand use. Having multiple replications of this study utilizing a single subject design or utilizing a group research design will verify the results of the data over and beyond the small number of students in this study.

Another limitation of this study is that the variation in student’s motor ability may have been responsible for the mixed results. Although the results of this study raise important issues
regarding the severity of motor movement and fatigue on word prediction use, more studies are needed across various types and severities of physical disabilities. Closer examination of the effects of word prediction software with students with more limited motor movement who use alternate access modalities would also be beneficial. Since the number of keypresses may be linked to fatigue, and word prediction software can reduce the number of keypresses, further studies are needed that assess keypresses and physical efficiency. Utilizing a fatigue measure as part of a future study would help determine the effects of fatigue on students’ writing.

Although this study did a one-year follow-up probe, further studies are needed examining the use of word prediction over time. Differences in typing speed may occur over multiple years. Also this study examined high school age students. Examining the effects of younger students who are beginning to learn to type and use word prediction may produce divergent results. Also, as technology continues to improve, studies are needed to examine the use of word prediction with newer features such as flexible spelling, as well as a variety of word prediction programs.

The data from this study indicated that there can be potential benefits of word prediction software for some individuals with physical disabilities that affect hand use. Two out of four students are continuing into their second year of using word prediction for their primary means of independent work output. If word prediction software improves motivation to type, decreases spelling errors, increases typing rate, or reduces fatigue, it can be a valuable tool for individuals with physical disabilities.