

Understanding Students' Typing Skills: Evaluating the Effects and Efficiency of a Typing
Intervention for Elementary School Students

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Abstract

Common Core State Standards require elementary school students to have sufficient keyboarding skills. Specifically, students are expected to use computers to produce a written composition in a single sitting. Despite Common Core State standards, students are not performing proficiently on computer-based writing assessments. Research suggests computers are not being used in writing instruction and comparisons of typed and handwritten assignments for elementary school students revealed that students type significantly less than they handwrite. Therefore, students may not have pre-requisite typing skills necessary to compose a quality typed composition. The purpose of the current study is to evaluate the effects of an online typing intervention on fourth- and fifth-grade students' writing performance.

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CHAPTER I

Review of the Literature

Writing is a foundational skill that is vital to academic, occupational, and social success (Graham, 2008; Kellogg & Whiteford, 2009). From writing a paper for publication to drafting a memo writing is a necessary skill required for participation and success in daily life (Graham & Perin, 2007). Despite the importance and necessity of writing, students across the United States do not possess adequate writing skills. On the 2011 computer-based National Writing Exam, less than one quarter of eighth-grade (24%) and twelfth-grade (24%) students performed proficiently (National Center for Educational Statistics [NCES], 2012) and 40% of fourth-grade students received a score indicating low or marginal writing skills for their grade level (White, Kim, Chen, & Liu, 2015). The majority of eighth-grade (54%) and twelfth-grade (52%) students performed at the basic level which “denotes partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade” (NCES, 2012, p. 7).

The percentage of eighth-grade and twelfth-grade students performing proficiently on the 2002 and 2007 paper-based National Writing Exam were similar to 2011 computer-based percentages. In 2007, only 31% of eighth-grade students and 23% of twelfth-grade students performed proficiently; the majority of eighth-grade (53%) and twelfth-grade (57%) students performed at the basic level, reflecting only partial mastery of grade-level writing skills (Salahu-Din, Persky, & Miller, 2008). In 2002, only 29% of eighth-grade students and 22% of twelfth-grade students performed proficiently; the majority of eighth-grade (52%) and twelfth-grade (48%) students performed at the basic level (U.S. Department of Education, 2003).

Results from the 2002, 2007, and 2011 National Writing Exams demonstrate that students across grade-levels have limited writing skills (NCES, 2012; Salahu-Din et al., 2008; U.S.

Department of Education, 2003). Graham and Perin (2007) suggested that writing education in schools is often insufficient. Neglect of writing skills occurs early in education, with two out of three fourth-grade students in the United States not writing well enough to meet classroom demands (Persky, Daane, & Jin, 2003). The neglect in early education is problematic as researchers suggest that students need to build strong literacy skill at a young age, especially in writing (Graham, Harris, & Santangelo, 2015; Slavin, Madden, & Karweit, 1989). Graham, McKeown, Kiuahara and Harris (2012) suggested that poor writing skills compounds across grades levels, resulting in a continual struggle for poor writers. Furthermore, students with inadequate writing skills are at increased risk for school failure and drop-out (Berninger et al., 2006).

Even students who graduate high-school are reported to have insufficient writing skills. On a survey, employers reported that many recent high-school graduates enter the workforce (38%) without the writing skills necessary to adequately perform their job (Achieve Inc., 2005). Of students directly entering the workforce, 39% indicate that their high-school education did not prepare them for their current job and 46% say that there are gaps between the preparation received in high school and the skills needed for future employment (Achieve Inc., 2005). These statistics are concerning as the National Commission on Writing (2006) reports that with the changing digital-world, 80% of blue-collar jobs and 90% of white-collar jobs now require writing. Furthermore, American companies are spending a substantial amount of money (over 3 billion dollars) each year on writing remediation for recent graduates (National Commission on Writing, 2004).

Writing skills deficits are also apparent in the university setting with an overwhelming percentage of college professors reporting dissatisfaction with high-school writing education

(Achieve Inc., 2005; Sanoff, 2006). High-school graduates also recognize their lack of skill with over half (56%) reporting that their high-school education did not prepare them for college (Achieve Inc., 2005).

Common Core State Standards

Common Core State Standards (CCSS) were created by state education chiefs and governors to ensure high-school graduates across the nation are receiving the same high-quality education (Common Core State Standards Initiative, 2018). CCSS were created as learning goals that specify skill mastery at the end of each grade level; however, the standards are not a curriculum. State educational officials are responsible for determining *how* students in their state should be instructed to gain skills necessary for meeting CCSS (Graham et al., 2015). Standards exist for kindergarten through twelfth grade in the areas of Math and English Language Art(ELA)/Literacy (Common Core State Standards Initiative, 2018). Because students are expected to learn literacy skills in a variety of content areas, the ELA/Literacy standards also include standards for History/Social Studies, Science and Technical Subjects, as well as Writing.

With CCSS, writing is placed at the center of educational reform and is emphasized as an important part of the curriculum across content areas (Graham & Harris, 2015). CCSS are notably more organized than previous writing standards and offer a clear progression of skill development (Shanahan, 2015). CCSS require writing to be an important aspect of education beginning in kindergarten (Common Core State Standards Initiative, 2018). According to CCSS, students are expected to 1) create compositions that persuade, inform, and narrate fictional or nonfictional experiences, 2) use writing to facilitate reading, learning, and construction of knowledge, and 3) use digital writing tools to express ideas (Graham et al., 2015). Furthermore,

students are expected to master foundational writing skills such as handwriting, typing, spelling, and grammar (Common Core State Standards Initiative, 2018).

While CCSS are well intentioned and set guidelines for student writing expectations across grade-levels, there is limited research on theoretical models of children's writing skills (Graham & Harris, 2015). It is difficult to know what writing skills are important and exactly when certain writing skills develop. Thus, creators of CCSS had to make educated guesses about which writing skills to focus on and when to focus on them (Graham & Harris, 2015). Further, there is limited support for current computer-based assessment procedures in the area of writing. While researchers suggest that computer-based assessments have many advantages (e.g., engaging for students, adaptive, may reduce floor and ceiling effects; Porter, McMaken, Hwang, & Yang, 2011), it is still unknown if young students have the necessary skills to adequately complete computer-based assessments. Students are now required to proficiently "use technology, including the Internet, to produce and publish writing and to interact and collaborate with others" (Common Core State Initiative, 2018); however, the inclusion of technology and computer-based assessments may be further exacerbating young students' already inadequate writing skills by requiring keyboarding for compositions. Starting in the third grade, students may be asked to compose a persuasive essay on the computer to assess writing skills (Fink, 2016). Fourth-grade students are expected to demonstrate sufficient command of keyboarding skills and be able to compose a one-page composition in one sitting; fifth-grade students are expected to demonstrate proficient keyboarding skills and be able to compose a two-page composition in one sitting (Common Core State Initiative, 2018).

Computer-Based Assessment

Computer-based assessments are now being used in areas of reading, math, and writing to measure progress toward CCSS (Fink, 2016); however, it is unclear if young students possess the skills necessary to perform adequately on computer-based assessments. In 2012, the National Assessment of Educational Progress (NAEP) conducted a pilot-test to assess fourth-grade students' writing in a computer-based format. White et al. (2015) reported that 68% of fourth-grade students received scores below three on a 1-6-point scale; of that 68%, many (40%) scored a one or two. Specifically, middle- and low-performing students performed poorly on the computer-based assessment. Middle and low-performing students typed fewer words (104 and 60, respectively) than high-performing students (179), thus widening the achievement gap (White et al., 2015).

Additionally, comparisons of typed versus handwritten compositions for elementary school students have revealed that students type less than they handwrite (Chwat, 2017; White et al., 2015). In a within-subjects comparison of third-, fourth-, and fifth- grade students typed versus handwritten responses to a 5-min writing curriculum-based measure (CBM), students' total words typed ($M=32.39$) was significantly lower than total words handwritten ($M = 38.41$; Chwat, 2017). Further, White et al. (2015) reported that the average total words produced on the 2012 computer-based NAEP writing assessment was lower (110 words) than the average total words produced on a 2010 paper-based NAEP writing assessment (159 words).

Chen, White, McCloskey, Soroui, and Chen (2011) cite two major concerns with computer-based assessments: 1) some individuals are unfamiliar with computers and 2) there may be a bias in evaluating computer versus handwritten responses. When assessing writing skills, Chen et al. (2011) found that adults took longer, on average, to compose computer-based

responses than handwritten responses. Furthermore, the researchers found that handwritten responses were of higher quality than computer-based responses (Chen et al., 2011). Other researchers suggest that computer-based assessment may exacerbate social barriers (Wolfe & Manalo, 2004). White et al. (2015) found that differences between high- and average/low-performing students on the 2012 NAEP computer-based writing assessment is related to prior exposure to writing on the computer. Across performance levels, students who spent less than one-hour a day on computer-based school assignments had a lower average writing score than students who spent more than one-hour a day on the computer. Thus, lack of access to a computer may inadvertently influence writing skills by way of unfamiliarity with the composition medium.

Computer-Based Education

Computer-based writing instruction may be important for success on computer-based assessments. A national survey conducted to examine the writing instruction practices of primary school teachers found that 42% of teachers do not use computers during writing instruction (Cutler & Graham, 2008). Of the 58% of teacher who reported using computers during writing instruction, a quarter (25%) only *sometimes* incorporated computers. A more recent survey of middle school teachers had similar findings. Middle school teachers had students use a word processor to complete less than half of their writing assignments (Graham, Capizzi, Harris, Hebert, & Morphy, 2014). Further, 69% of middle school teachers reported that they never use computer software program to teach writing and many teachers (45%) only allow students to use the internet to locate information for a writing assignment a few times a year (not for every assignment; Graham et al., 2014).

Thus, many students are not being explicitly taught how to write and compose compositions on the computer. The lack of specific computer-based writing instruction is reflected in student typing techniques. On the NAEP 2012 computer-based assessment, fourth-grade students often used the hunt-and-peck method or only used one hand to type (White et al., 2015). Thus, White et al. (2015) suggested that it would be advantageous for fourth-grade teachers to focus on teaching students “how to compose at the keyboard.” Christensen (2004) found that typing ability accounted for 29% of variance in the quality of typed text and 30% of the fluency. These results indicate that automaticity in typing may enhance the quality of typed compositions.

Recommendations for Computer-Based Assessment

Researchers have made recommendations for how and when computer-based assessment should be used in writing. Rogers and Case-Smith (2002) asserted that typing should only be used as an alternative to handwriting when students can type at an adequate speed. Balajthy (1988) suggested that a student’s typing speed should be, at least, equivalent to their handwriting speed for typing to be used as an alternative to handwriting. While Graham et al. (2012) suggested that students should be introduced to keyboarding in first-grade, should have regular practice with keyboarding by second-grade, and should be able to type as fast as they handwrite by third-grade, Horne, Ferrier, Singleton, and Read (2011) found that typing speed does not typically exceed handwriting speed until students are 14- years old (i.e., 8th grade); findings are consistent with previous research comparing eighth-grade students’ (i.e., 14-years old) writing performance on computer- and paper-based assessments (Horkay, Bennett, Allen Kaplan, & Yan, 2006; White et al., 2015). Horkay et al. (2006) found that eighth-grade students scored similarly on computer-based (3.5) and paper-based (3.6) assessments and that students produced

slightly more words on the typed essay (185) than the handwritten essay (176). Furthermore, NAEP data indicated that eight-grade students did produce more words on the computer-based assessment (300) than the paper-assessment (155), while fourth-grade students did not (110 typed; 159 handwritten; White et al., 2015).

Theories of Writing

Researchers suggest that writing is a complex process that requires the coordination of many cognitive processes (Berninger et al., 2002; Deane et al., 2008; Flower & Hayes, 1981). To compose a composition, a writer must plan and organize ideas, transcribe those ideas, and maintain attentional focus. According to Flower and Hayes (1981) there are three major elements of the act of writing: the task environment, the writer's long-term memory, and the writing process. The task environment includes all external factors, such as the writing assignment. The writer's long-term memory contributes background knowledge on the topic as well as knowledge of the audience. The writing process involves planning, translating, and reviewing.

Cognitive process theory. According to Flower and Hayes' (1981) Cognitive Process Theory, planning involves the internal representation that the writer will use to create a composition. With planning, the writing assignment and long-term memory (e.g., background knowledge of topic and audience) serve as the input (Deane et al., 2008). The writer uses the input to generate ideas, organize ideas, and set goals. Planning is followed by translating, which is the process of putting ideas on paper, or computer (Flower & Hayes, 1981). Hayes (2009) suggests that the speed of translating is largely influenced by the writer's linguistic knowledge as well as the writer's working, or short-term, memory. Reviewing is the final stage of the Cognitive Process Theory and consist of evaluating and revising (Flower & Hayes, 1981).

Transcription. Later iterations of Flower and Hayes' model suggest that transcription follows the translation process (Hayes, 2009). Transcription is the act of applying grammar, spelling, and good written (or typed) form to the ideas that were translated. For inexperienced writers, the transcription process may overburden working, or short-term, memory (Flower & Hayes, 1981). Transcription often requires young students and inexperienced writers to devote additional attention to the processes of spelling, grammar, and text generation. Thus, less attention can be devoted to global processes of writing such as planning or organization. For example, Bourdin and Fayol (2000) found that transcription can require a high level of cognitive resources, to the point that transcription interferes with word storage. Thus, Hayes (2009) suggests that transcription is the bottleneck that limits fluency in elementary school students. Deane et al. (2008) suggest that transcription must become automatic for the writing process to function effectively.

The simple view of writing. Another popular theory of writing development is described by Virginia Berninger. Berninger's theory is known as "the simple view of writing." According to the simple view of writing, writing is a complex task requiring transcription (e.g., handwriting, typing), text generation (e.g., words, sentences) and executive functioning skills (e.g., attention, planning). Similar to Flower and Hayes' revised theory, Berninger et al. (2002) describes how transcription plays an important role in the development of young writers.

According to Berninger et al. (2002), typing is part of the transcription process of the simple view of writing. Transcription is the first skill to develop and requires skills in forming letters (handwritten or typed), spelling, capitalization, and punctuation (Hayes & Olinghous, 2015). Researchers have demonstrated that improved transcription skills lead to increases in writing quality (Berninger & Amtmann, 2003; Christensen, 2004; Jones & Christensen, 1999).

Interventions designed to improved handwriting (Berninger & Amtmann, 2003; Jones & Christensen, 1999), spelling (Berninger & Amtmann, 2003), and typing (Christensen, 2004) skills caused improvements in the quality of writing whether handwritten or typed. In the Christensen (2004) study, a typing intervention was implemented, and students' quality of typed compositions improved, but not the quality of handwritten compositions. Hayes and Olinghous (2015) suggested that the relationship between transcription skills and writing performance can be explained in two ways: 1) transcription is cognitively demanding and too few available cognitive resources are left for other writing processes and 2) young children have difficulty with transcription (due to developing motor skills) and therefore are less motivated to engage in writing.

Once transcription becomes automatic, more cognitive resources can be devoted to text generation and executive functioning (Hayes & Olinghous, 2015). While Graham et al. (2012) suggested that typing speed be equivalent to handwriting speed by third grade, previous research (Chwat, 2017; White et al., 2015) found that fourth- and fifth-grade students are not typing as many words as they handwrite. Thus, typing may not be automatic for those students and likely requires a high level of cognitive resources (Connelly, Gee, & Walsh, 2007). The large cognitive demand and working memory devoted to transcription (i.e., typing) leaves fewer cognitive resources available for other writing processes (Connelly et al., 2007). Thus, Connelly et al. (2007) suggested that students who are slow at typing, will produce poorer compositions than proficient keyboarders because they must devote large amounts of cognitive resources to transcription.

Need for Keyboarding Interventions

Based on theory (Berninger et al., 1992; 2002; Hayes & Olinghouse, 2015), research (Horne et al., 2011; White et al., 2015), and previous suggestions (Balajthy, 1988; Connelly et al., 2007; Rogers & Case-Smith, 2002), younger students, and students with limited typing ability, are at a disadvantage when their writing is evaluated using a computer-based format. Yet, it is unlikely that assessment procedures will change due to the adoption of CCSS. Thus, interventions need to be designed and implemented to help students improve their typing skills to an appropriate level. According to Graham et al. (2012), once basic typing skills are learned, students can focus on developing and communicating their ideas instead of on basic typing skills. Researchers suggest that teachers should promote typing fluency by instituting regular typing lessons that are short and focused (Graham et al., 2012). Further, the researchers advocate for explicit instruction – teaching students to use the correct finger and to type without looking at the keyboard – and repeated practice to improve fluency and accuracy.

Graham et al. (2012) recommendations are supported by theory and previous research. Berninger et al. (2006) described that repeated exposure and practice with transcribing (e.g., typing) can enhance skills and Skinner (1998) suggested that providing time to practice new skills increases learning. Additionally, Haring and Eaton (1978) explained that instruction during the acquisition phase of skill development should include modeling, prompting of the skill, and repeated practice. Immediate corrective feedback is also beneficial in promoting skill development and accuracy (Wright, 2003). Interventions utilizing such techniques (e.g., repeated practice, modeling, immediate corrective feedback) have been found effective at promoting skill development (e.g., Nies & Belfiore, 2006; McLaughlin & Skinner, 1996; Poncy, Skinner, & Jaspers, 2007).

While it is likely that enhanced typing skills will improve computerized writing outcomes, few studies have examined the impact of typing fluency/speed on writing outcomes. Further, few studies have examined the impact of repeated practice, modeling, and immediate corrective feedback on typing fluency/accuracy. Most studies have focused on instruction in word processing and rudimentary typing skills.

Word-Processing. In 1994, Jones conducted a word-processing-based intervention with second-grade students. Students completed a paper-based pretest and were then placed into intervention and control groups. Both groups received daily language-arts instruction from their teacher and completed seven individual writing assignments. For the intervention group, instruction was aided by a word-processing learning tool and students completed all writing assignments using the word-processing program. For the control group, instruction was paper-based, and all writing assignments were completed in paper format. After four weeks, both groups completed a paper-based posttest. Posttest scores of writing quality and word count were significantly higher for the intervention group than the control group when controlling for pretest writing quality.

After the posttest, the researcher reversed the groups (Jones, 1994). The intervention group became the control group, receiving paper-based instruction and completing paper-based writing assignments; The control group became the intervention group, receiving word-processing instruction and completed writing assignments on the word-processing program. After four weeks, both groups completed another paper-based posttest. Posttest scores of writing quality and word count did not differ between the two groups. Thus, Jones (1994) concluded that the original intervention students maintained the same level of writing quality and word count between the first and second posttest, while the second intervention group improved their

writing quality and word count only after receiving the intervention. Therefore, both groups were expected to perform similarly on the second posttest.

While Jones (1994) did use a word-processing program to improve writing quality, data were not reported on students' typed writing quality. Furthermore, Jones (1994) did not describe any specifics of the implemented word-processing intervention, other than saying that the teachers provided instruction. Thus, it is unknown if students received any typing instruction or if instruction pertained purely to the word-processing program. While the word-processing intervention did increase writing quality in both groups (Jones, 1994), it is unclear why word-processing instruction would improve handwritten writing quality. Jones (1994) hypothesized that the word-processing program provided a facilitative format enabling students to focus on generation of ideas and revisions, as opposed to transcription. Jones (1994) also postulated that working with the word-processing program may have changed students' attitudes toward writing, resulting in higher motivation and prolonged engagement with paper-based writing assignments. Overall, Jones (1994) made no attempt to identify variables that would assist in the transfer of writing quality between word-processing instruction and paper-based writing quality. Therefore, additional interventions are needed to examine causal mechanisms and to investigate possible extension of results to typed writing quality.

Typing. Christensen (2004) conducted an intervention to improve typing speed of eighth-grade students with low typing proficiency. Students participated in small-group instruction led by a tutor for 20 min a day for 8 weeks. The instruction consisted of a typing skills program that allowed students to practice typing strings of letters, words, phrases, and sentences. The program began with strings of two letters that progressively grew to three letters, then four, followed by words, phrases, then sentences. Students progressed to the next stage

(i.e., from strings of two letters to strings of three letters) when they typed at 40 letters per minute. The criterion was selected because it was the mean typing speed in a previous study. Christensen (2004) found that students participating in the intervention improved the quality of typed-text from pretest to posttest; students in the intervention group also had higher writing quality scores than a control group.

Results of this intervention indicated that repeated practice and explicit typing instruction can improve typed writing compositions, even with students who begin with limited typing ability. Consistent with the simple view of writing, Christensen (2004) concluded that the intervention students developed a proficiency in typing which allowed them to use cognitive resources more effectively. Thus, similar typing interventions should be used with younger students to improve typing skills and allow for allocation of cognitive resources to text generation and executive functioning tasks.

Summary

Writing is an important skill necessary for academic and workplace success (Graham, 2008; Kellogg & Whiteford, 2009). Yet, students across grade-levels possess inadequate writing skills (e.g., NCES, 2012; Salahu-Din, 2008, White et al., 2015). On the most recent National Writing Exam, less than a quarter of eighth- and twelfth-grade students performed proficiently (NCES, 2012). Researchers suggest that students are receiving inadequate writing education and that poor writing skills are compounding across grade-levels (Graham, McKeown et al., 2012). With the trend of poor writing performance (NCES, 2012; Salahu-Din, 2008, U.S. Department of Education, 2003) and a desire to create high quality standards across the United States in mind, state educational chiefs and governors created CCSS (Common Core State Initiative, 2018).

CCSS created guidelines and benchmarks for skill mastery at the end of each grade level (Common Core State Initiative, 2018). The standards include specific guidelines for writing and require students to 1) write persuasive, informative and narrative compositions about fictional or nonfictional experiences, 2) use writing to facilitate reading, learning, and construction of knowledge, and 3) use digital writing tools to express ideas (Graham et al., 2015). CCSS expect students to use technology during writing and computer-based assessments are being used to monitor progress toward CCSS (Fink, 2016).

While CCSS are well intentioned and create much needed guidelines in the area of writing, the use of computer-based assessments to monitor progress may be further exacerbating writing skills of young students. While Graham et al. (2012) suggested that students should be able to type as quickly as they handwrite by third-grade, previous researchers suggest that third- fourth- and fifth-grade students may not possess the typing skills necessary to produce quality typed compositions (Chwat, 2017; White et al., 2015). Further, national surveys of elementary school teachers indicate that most teachers do not feel their college training prepared them to teach writing (Gilbert & Graham, 2010) and rarely use computers during writing instruction (Cutler & Graham, 2008). Thus, assessing writing performance with a computer-based assessment may not be the most accurate way to measure writing skills in elementary-school students; however, with the adoption of CCSS by many states, computer-based assessments will continue to rise, and it is likely that elementary school students will continue to be asked to produce writing compositions on the computer.

Purpose

The purpose of the current study was to evaluate the effectiveness of an intervention designed to improve student typing speed. The current study focused on fourth- and fifth-grade

students' writing and typing skills. A between- and within-subject design was used to examine the effects of the intervention on student typing speed and on the quality of student typed responses (i.e., total words typed and correct typing sequences). Further, based on previous suggestion (Balajthy, 1988) that students need to type as quickly as they handwrite to compose similar typed and handwritten compositions, the current study examined the discrepancy between handwriting speed and typing speed.

Research Questions and Hypotheses

Research Question 1. Did participation in the typing intervention improve student typing speed (i.e., words per minute)? Based on previous research suggesting that providing time to practice new skills increases learning (Skinner, 1998), it was hypothesized that participation in a typing intervention will lead to increases in typed speed. Further, Christensen (2004) found that eighth-grade students' typing speed increased following explicit typing instruction.

Research Question 2. Did participation in the typing intervention influence the discrepancy between handwriting speed (i.e., handwriting words per minute) and typing speed (i.e., words per minute)? Because the typing intervention is designed to improve typing speed, not handwriting speed, it was hypothesized that the discrepancy between handwriting speed and typing speed will decrease following the intervention. Specifically, it was hypothesized that students' handwriting speed will be higher than student typing speed prior to intervention, but students' typing speed will approach, or exceed, handwriting speed following intervention.

Research Question 3. Did participation in the typing intervention improve the quality of typed stories? Based on previous research (Christensen, 2004), theory (Berninger et al., 2002), and recommendation (Graham et al., 2012), it was hypothesized that participation in a typing

intervention designed to increase typing speed will lead to improvements in the quality of typed stories. Christensen (2004) found that eighth-grade students' participation in a typing intervention resulted in improved quality of typed responses. Furthermore, according to the simple view of writing (Berninger et al., 2002), increased transcription (i.e., keyboarding) skills will lessen the amount of cognitive resources required to accurately transcribe a story. Thus, additional cognitive resources can be allocated to other writing processes such as text generation and executive functioning skills. Similarly, Graham et al. (2012) suggest that if student master foundational skills, such as typing, more attention can be focused on strategic writing behaviors and strategies. Graham et al. (2012) assert that teaching students to type will allow students to compose typed compositions more easily.

Research Question 4. Did participation in the typing intervention influence the discrepancy between handwritten story quality (i.e., Correct Writing Sequences) and typed story quality (i.e., Correct Typing Sequences)? Based on previous research (Christensen, 2004), it was hypothesized that the discrepancy between handwritten story quality and typed story quality will decrease following the intervention. Specifically, students' typed story quality will improve, while students handwritten story quality will not. Christensen (2004) found that following a typing intervention, students' typed story quality improved but no differences were found between pretest and posttest handwritten story quality.

Research Question 5. Did the typing intervention have social validity for students and/or teachers? Based on previous research (Wanzek et al., 2006), it was hypothesized that students will enjoy the typing intervention. Wanzek et al. (2006) suggests that computer-based interventions are engaging and often motivate students. Further, it is hypothesized that students will find the intervention helpful will report that the intervention improved their typing and

writing performance. It is further hypothesized that classroom teachers will enjoy the intervention because it requires minimal teacher effort and because it is hypothesized to improve student typing and typed writing performance.

CHAPTER II

Method

Participants

University IRB approval was obtained, and data were collected from 134 students. Of the 134 students, 54% were male, 44% female were female, and 2% indicated that they preferred not to answer. Students were in the fourth- (n = 74) and fifth-grade (n = 60) across eight classrooms at a South-Eastern public elementary school. Classes included four fourth-grade classrooms and four fifth-grade classrooms. All eight classroom teachers consented to participate and signed a teacher consent form (see Appendix A). Each teacher distributed and collected consent/assent forms (see Appendix B). Consent/assent was obtained 101 students. Only students with signed consent/assent forms are included in this analysis; however, all 134 students participated in study procedures.

Settings and Materials

All data (i.e. pretest, intervention, posttest) were collected in the student's typical classroom. Students used school provided laptop to complete pretest activities, visit www.typing.com, and complete posttest activities.

Study materials included UTK IRB approved consent/assent forms, school provided laptop computers, pencils, and research packets (Appendix C). Research packets included a username, password, prompt for handwriting speed task, blank paper, prompt for typing speed task, and a curriculum-based measure (CBM) in written expression. The prompts for the handwriting and typing speed test included variations of the sentence "the quick brown fox jumps over the lazy dog" (see Appendix C; Berninger et al., 1997; Connelly et al., 2007; Klein, Guiltner, Sollereder, & Cui, 2011). The sentence used all 26 letters of the alphabet. Variations

of the sentence were presented with randomized word order to reduce the possibility of order effects. The writing CBM consisted of blank lined paper with a story starter (e.g., My favorite T.V. show is ...) typed across the top. Other study materials included researcher-developed scripts for pretest administration (Appendix D), teacher implementation (Appendix E), posttest administration (Appendix F) and procedural integrity checklists (Appendix G, H, and I). Materials also included a researcher-developed online survey (Appendix J) and researcher-developed social validity surveys for students (Appendix K) and teachers (Appendix L).

Dependent Measures

Handwriting and typing speed. To assess student handwriting and typing speed, students copied variations of the sentence “the quick brown fox jumps over the lazy dog” (see Appendix C). Each sentence contained all 26 letters of the alphabet. Students were allowed 2-min to copy as much as they could. Students were asked to copy the sentences as quickly as they could and to copy the sentences exactly like the prompt.

To measure handwriting and typing speed, Words Per Minute (WPM) was calculated. WPM was calculated by counting the total number of characters produced, including spaces, during the 2 min speed test and dividing that number by 5 (the average length of words; Rogers & Case-Smith, 2002). Errors were also calculated during both 2 min speed test to measure accuracy; any omitted, additional, or incorrect letter counted as an error (Rogers & Case-Smith, 2002).

During the intervention, all students completed a 1-min typing speed test on www.typing.com. All intervention typing test scores (i.e., WPM, accuracy) were recorded on www.typing.com. At the end of the week, researchers recorded intervention typing speed data from www.typing.com.

Lessons completed. For all students in intervention classrooms, data was obtained via www.typing.com regarding the number of lessons completed. Lessons were the same across students and all students began at the first lesson. To complete a lesson, students had to progress through a series of activities, speed drills, and repeated practices for each letter(s) of focus. After 10 weeks of intervention, the primary researcher obtained data on the number of lessons completed by each student and entered it in the study database.

Writing and typing performance. To assess writing production and quality, students completed a 5-min handwritten and a 5-min typing CBM. Students were given a story starter (e.g., My favorite T.V. show is ...) and allowed 1-min to plan their story. After 1-min students were given 5-min to write or type.

Total words. To measure writing production, Total Words Written (TWW) was calculated for handwritten responses and Total Words Typed (TWT) was calculated for typed response. TWW is a measure of writing production and was used to make comparisons between typed (TWT) and handwritten (TWW) responses. TWW is a count of all words produced and spelling, grammar, and syntax are ignored (Powell-Smith & Shinn, 2004). TWW has adequate reliability as demonstrated by McMaster and Campbell (2007), who found reliability to range between .60 and .76. Jewell and Malecki (2005) demonstrated criterion validity by correlating TWW with the Stanford Achievement Test, Ninth Edition. Further, TWW has also been correlated with overall writing quality (Powell-Smith & Shinn, 2004) and has a strong correlation with CWS for elementary school students (Gansle, VanDerHeyden, Noell, Resetar, & Williams, 2006).

Correct sequences. To measure writing quality, Correct Writing Sequences (CWS) were calculated for handwritten response and Correct Typing Sequences (CTS) were calculated for

typed response. Previous researchers suggest that CWS are similar to TWW but also accounts for spelling, grammar, and syntax and was used as a measure of writing quality (Jewell & Malecki, 2005). A correct writing sequence consists of two adjacent writing units that are correct in context; words and punctuation must be mechanically, semantically, and syntactically correct (Powell-Smith & Shinn, 2004). CWS has adequate reliability as demonstrated by McMaster and Campbell (2007), who found reliability to range between .57 and .68 for third-, fifth-, and seventh-grade students. As with TWW, Jewell and Malecki (2005) demonstrated criterion validity by correlating CWS with the Stanford Achievement Test, Ninth Edition. The researchers found that correlations between CWS and the Stanford Achievement test were higher than correlations between TWW and the Stanford Achievement Test. Thus, CWS may be more appropriate when predicting performance on standardized assessments.

Independent Variable

The independent variable was the typing intervention. The typing intervention consisted of lessons, games, and typing test on www.typing.com. The typing website was selected for multiple reasons: www.typing.com is 1) free to use, and 2) utilizes evidence-based practices such as repeated practice, modeling, and corrective feedback.

Based on suggestions from Graham et al. (2012) to provide elementary school students with regular typing interventions that are short, but focused, the intervention was delivered 3 days a week for 10 min across 10 weeks. The intervention consisted of typing activities such as lessons and games that allowed students to practice typing. Lessons were split into beginning, intermediate, and advanced levels. All students started with the beginning level and progressed at their own speed through each lesson. Lessons consisted of instruction on location of keys as well as speed drills that allowed for practice of certain keystrokes. For example, the first lesson

focuses on typing ‘J’ and ‘F.’ The lesson began with the directions “Welcome to Typing.com! We are going to start off really easy. On the next screen, just type the letter J with your right index finger.” Directions were accompanied with an image of a virtual keyboard with the “J” key highlighted and a transparent hand showing to use the right index finger (see Appendix M). The lesson continued with typing practice of the letter “J,” followed by practice typing the letter “J” and the space bar. The lesson then moved to the letter “F” and repeats the process. Next speed drills were introduced where, “J,” “F,” and the space bar are practiced together.

Students completed their assigned typing lessons 2 days a week. On the third day, students played one of the nine typing games available on <https://www.typing.com/student/games>. The typing games required students to type letters or words to progress through the game. For example, the game ZTYPE, which is similar to the arcade game Galaga, required students to shoot incoming words by typing the appropriate letters. If students did not type the words fast enough, the words would hit their spaceship and end the game. Every week, after 9-min of typing games, students were instructed to click the Test tab to take a 1-min typing test.

Procedures

Following IRB approval, teachers at the elementary school were contacted. Willing teachers were asked to sign a consent form (Appendix A). Consent/assent forms were provided to participating classroom teachers, who distributed them to, and collected them from, fourth- and fifth-grade students. All students in participating classrooms participated in the study; however, data was only analyzed from students with signed consent/assent.

Researcher training. Researchers participated in training to ensure there was integrity in all data collection procedures (i.e., pretest, intervention, posttest). During training, the

primary researcher trained supporting researchers on administration of all relevant data collection and implementation scripts. To further ensure study procedure were implemented with integrity, two trained researchers in a School Psychology Ph.D. program were present for each pretest and posttest administration.

All supporting researchers were students in a School Psychology Ph.D. program as well as members of a research team that focuses on writing research. As members of the research team, supporting researchers have conducted studies with similar procedures in regard to writing (e.g., administration and scoring of writing CBMs).

Pretest. All students took part in pretest data collection activities. During pretest data collection, a primary researcher introduced the study and provided directions using a researcher developed script (Appendix D). A secondary researcher completed a procedural integrity checklist to ensure all pretest procedures are followed with integrity (Appendix G). The pretest included five sections: 1) a 2-min typing speed test, 2) a 2-min handwriting speed test, 3) a writing CBM to type, 4) a writing CBM to handwrite, and 5) a demographic questionnaire. All pretest sections were presented using an online survey (Appendix J). Order of the typing and handwritten speed test as well as the typing and handwritten CBMs were randomized. Further, similar story starters were selected for the typed and writing CBMs and the prompts were counterbalanced. Narrative story starters were selected because previous researchers suggest that narrative story prompts are the most reliable probe for elementary school students (McMaster & Campbell, 2008; McMaster, Du, & Petursdottir, 2009). All students completed each of the five sections of the online pretest survey (i.e., 2-min typing speed test, 2-min handwriting speed test, typed CBM, handwritten CBM, and demographic questionnaire). All possible order

combinations are presented in Appendix N. Student research packets were created for each student (see Appendix C for an example research packet).

Typing speed test. Students completed a 2-min typing test in which they were asked to type variations of the sentence “the quick brown fox jump over the lazy dog” (Berninger et al., 1997; Connelley et al., 2007; Klein et al., 2011). The sentence was presented as written as well as with randomized word order to minimize the possibility of memorization. Students will be provided a piece of paper with the sentences to copy in their research packet (Appendix C).

Handwriting speed test. Students completed a 2-min handwriting speed test. The handwriting speed test followed the same procedure as the typing speed test except students wrote the sentences instead of typing. Students were provided a piece of paper with sentences to copy and a piece of blank lined paper to copy the sentences on (Appendix C).

Typed story using writing CBM procedures. Students were given 1 min to plan their story followed by 5 min to type their story. The typing CBM was administered using standard CBM in Written Expression procedures (Appendix O).

Traditional writing CBM. Students were prompted to turn to the final page of their research packet where they found blank lined paper with a story starter typed across the top. Students were given 1 min to plan followed by 5 min to handwrite. The handwritten CBM was administered using standard CBM in Written Expression procedures (Appendix O).

Demographic questionnaire. Students were asked demographic questions about age, gender, grade, race, ethnicity, and previous typing instruction.

Intervention assignment. Pretest data was used to examine each classroom and to select matched control classrooms. Classrooms were matched to ensure that participants in the control group and intervention group were as equivalent as possible prior to intervention. Because the

intervention was designed to improve typing speed, student typing speed data was examined to determine matching. Typing speed data was calculated for each student. Mean typing speed was examined by classroom to assign each classroom to an intervention or control group (see Appendix P) for classroom typing speeds and a thorough description of the process used to select intervention and control classrooms.

Intervention. Following pretest data collection, a primary researcher introduced students to the intervention. In intervention classrooms, students engaged in the typing intervention approximately 3 days a week for 10 min a day. On the third day of the week, students played typing games for 9-min then took a 1 min typing test using the Test tab on <https://www.typing.com/student/test>. In the control classrooms, students did not engage in the typing activities or games but did take a 1 min typing test each week. All students used the same username and password provided on the first page of their research packet during pretesting (see Appendix C). After the initial introduction by a primary researcher, classroom teachers implemented the all procedures independently. Teachers followed a researcher developed script for the typing lesson, typing games, and typing test implementation (Appendix E).

Posttest. Posttest data collection activities followed similar procedures as pretest procedures; however, students completed a social validity survey instead of the demographic questionnaire. The social validity scale (Appendix K) was developed by the primary researcher and contained 12 Likert-style questions on a scale of 1 (*strongly agree*) to 4 (*strongly disagree*). Posttest data collection included the following five sections: 1) a 2-min typing speed test, 2) a 2-min handwriting speed test, 3) a writing CBM to type 4) a writing CBM to handwrite, and 5) a social validity survey. New narrative story starters were selected to ensure no student received the same prompt as in pretest. Story starters were counterbalanced, and presentation order was

randomized to reduce the possibility of order effects. A primary researcher provided directions following a researcher developed script (Appendix F).

Teacher social validity. Social validity was also assessed from the teacher's perspective. At the conclusion of the study, teachers in interventions classrooms completed a researcher-developed social validity scale (Appendix L). The scale contained 10 Likert-style questions on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*).

Procedural Integrity

To ensure pretest and posttest data were collected with integrity, a primary researcher introduced the study, provided directions (see Appendix D and F), and monitored the room. A second trained researcher completed a researcher-created procedural integrity checklist for the pretest (Appendix G) and posttest (Appendix I). Checklists were derived from relevant scripts. Procedural integrity was calculated by taking the total number of items completed and dividing it by the total number of items on the checklist and multiplying by 100. Procedural integrity across pretest and posttest was calculated at 100%.

To ensure integrity during intervention sessions, teachers followed a researcher prepared script (Appendix E). During approximately 30% of sessions, a trained researcher completed a procedural integrity checklist – either in person or via an audio recorded by the classroom teacher. Procedural integrity checklists were created for intervention sessions and typing test sessions (Appendix H). The appropriate checklist was completed for each classroom on each visit/each audio. Procedural integrity was calculated by taking the total number of items completed correctly and dividing it by the total number of items and multiplying by 100. This assessment of procedural integrity will ensure all students (intervention and control) are

completing sessions as expected. Procedural integrity was calculated at 100% across intervention and control classrooms.

Interscorer Agreement

To ensure all data were reliably scored, the primary researcher trained supporting researchers on scoring procedures for handwriting WPM/accuracy, typing WPM/accuracy, TWW, TWT, CWS, and CTS. Supporting researchers independently scored 3 writing samples for TWW and CWS as well as 3 writing samples for TWT and CTS. Supporting researchers were then trained to score handwritten and typed WPM as well as accuracy. Supporting researchers independently scored samples for WPM and accuracy. Samples were examined for reliability and supporting researchers did not score study data until agreement is above 90% for each dependent variable.

Only trained researchers scored written and typed response for handwritten WPM/accuracy, typed WPM/accuracy, TWW, TWT, CWS, and CTS. To ensure reliability in scoring, a second trained researcher, trained to 90% accuracy, independently scored 30% of written responses for handwritten WPM/accuracy, TWW and CWS as well 30% of typed responses for typed WPM/accuracy, TWT and CTS.

Interscorer agreement for all dependent variables (i.e., WPM/accuracy, TWW, CWS, TWT, CTS) was calculated by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying by 100. Interscorer agreement was calculated for each dependent variable. Overall reliability was calculated at 97.52%. Descriptive statistics for each dependent variable across pretest and posttest are displayed in Table 1.

For typing speed data obtained from www.typing.com, a trained researcher entered all collected data in a database. A second trained researcher confirmed accuracy of data entry by

independently reviewing 30% of all entered data. A secondary researcher confirmed that 98% of typing speed data entered was accurate based on data obtained from www.typing.com. For the 2% of entries where a discrepancy was found, both researchers simultaneously checked www.typing.com to determine which value should be entered into the database and made the appropriate correction if necessary.

Data Cleaning

Data were analyzed using SPSS 25 and were cleaned according to Morrow and Skolits' (2015) process. Of the 134 students from whom data was collected only 101 had signed consent/assent. Students without consent/assent were excluded from analyses. With the 101 students, initial frequencies were performed for all variables. Frequencies were examined for coding errors and missing data. Examination of frequencies revealed that 3 students missed more than five weekly typing tests. Because these students missed half, or more, of the weekly typing test they were excluded from analyses. Thus, the analyses included a total of 98 students.

Outliers. Outliers were assessed according to Tabachnick and Fidell's (2013) criterion. Z-scores were created for each dependent variable and examined to see if any z-scores were greater than 3.29 standard deviations above or below the mean. In total, z-scores were greater than 3.29 standard deviations from the mean. Each value was Winsorized to be exactly 3 standard deviations from the mean (Aguinis, Gottfredson, & Joo, 2013).

Normality. Normality was assessed using Kline's (2005) criteria. Data with a skewness greater than /3/ and kurtosis greater than /10/ were considered non-normal. One variable (Pretest Handwritten WPM) had a skewness of greater than 3 and a kurtosis greater than /10/. To further examine normality, a Shapiro-Wilk test was conducted. Analysis revealed that the distribution was not normally distributed, $SK(98) = .77, p < .001$. Because the assumption of normality was

violated, a more stringent alpha value ($p < .01$) was used to determine significance when this variable was used. All other variables were treated as normal and no modifications were necessary.

CHAPTER III

Results

Following data cleaning procedures (see description in method section), a total of 98 fourth- (n = 49) and fifth-grade (n = 49) students were included in the analyses. Of the 98 students, 56 were in intervention classrooms and 42 were in control classrooms. Preliminary analyses as well as results for each research question are described below.

Preliminary Analyses

Between-subject analyses. Student scores on all dependent variables were analyzed using descriptive statistics. Table 2 displays measures of central tendency (i.e., mean, standard deviation, range) for all pretest data. Data were disaggregated by treatment group (i.e., control, intervention). Overall students performed similarly across all pretest variables regardless of treatment group. Independent samples t-test were conducted to examine mean difference between control and intervention scores across all pretest variables and no significant differences were found.

Posttest data were also analyzed using descriptive statistics. Table 3 displays measures of central tendency (i.e., mean, standard deviation, range) for all posttest data. Data were disaggregated by treatment group (i.e., control, intervention). Overall students performed similarly across all posttest variables regardless of treatment group. Multiple independent samples t-test were conducted to examine mean difference between control and intervention scores across all posttest variables and no significant differences were found.

Student scores on the weekly typing test were also analyzed using descriptive statistics. Table 4 displays all intervention data (i.e., typing WPM, accuracy). Data were disaggregated by treatment group (i.e., control, intervention). Typing speed and accuracy scores were similar each

week, regardless of treatment group. No significant difference emerged between treatment groups across the 10-week intervention period.

Within-subject analyses. Handwriting/typing speed as well as writing outcomes (i.e., production, quality) were examined within-subject to analyze the difference between handwritten and typed responses. At pretest, no significant differences were found between treatment groups (i.e., control, intervention) on any speed variables or writing outcome (see Table 2). Similarly, no significant differences were found between treatment groups (i.e., control, intervention) on any speed variables or writing outcomes (see Table 3) at posttest. Thus, the following *preliminary* within-subject analyses were performed using the aggregated data set at pretest and posttest.

Pretest Variables. Table 5 displays descriptive statistics for pretest variables (i.e., speed, accuracy, total words, correct sequences) disaggregated by response format (i.e., handwritten, typed). A Dependent Samples t-test revealed a significant difference between student handwriting speed ($M = 11.64$, $SD = 4.94$) and student typing speed ($M = 10.21$, $SD = 4.22$), $t(97) = -2.62$, $p < 0.01$. Students produced significantly more characters on the handwriting speed test than on the typing speed test. Accuracy, however, was similar across the handwriting speed test ($M = 86.33$, $SD = 15.63$) and the typing speed test ($M = 86.76\%$, $SD = 13.45$); no significant differences emerged, $t(97) = 0.22$, $p = 0.83$.

At pretest, there was a significant difference between the total number of words produced on the handwritten CBM ($M = 53.61$, $SD = 18.67$) and the total number of words produced on the typed CBM ($M = 48.96$, $SD = 22.30$), $t(97) = 2.12$, $p < 0.05$. Students produced significantly more words on the handwritten CBM than on the typed CBM (see Table 5). When data were disaggregated by grade, a significant difference between production on handwritten and typed

CBM emerged for fifth-grade students, but not for fourth-grade students. Students in the fourth-grade ($n = 49$) produced a similar amount of words on the handwritten CBM ($M = 52.88$, $SD = 18.68$) and the typed CBM ($M = 48.30$, $SD = 25.29$), $t(48) = -1.35$, $p = 0.18$. Conversely, students in the fifth-grade ($n = 60$) produced significantly more words on the handwritten CBM ($M = 55.56$, $SD = 19.49$) than on the typed CBM ($M = 49.85$, $SD = 19.09$), $t(51) = -2.01$, $p < 0.05$ (see Table 6).

At pretest, there was also a significant difference between story quality, as measured by correct sequences, on the handwritten CBM ($M = 49.29$, $SD = 19.72$) and on the typed CBM ($M = 39.00$, $SD = 21.57$), $t(98) = -5.12$, $p < 0.001$. Story quality was significantly higher on the handwritten CBM than on the typed CBM (see Table 5). A significant difference between quality on handwritten and typed CBM also emerged when data were disaggregated by grade. Students in the fourth-grade ($n = 47$) produced significantly more correct sequences on the handwritten CBM ($M = 48.09$, $SD = 19.35$) than on the typed CBM ($M = 36.66$, $SD = 23.94$), $t(46) = -3.57$, $p < 0.01$. Similarly, students in the fifth-grade ($n = 62$) produced significantly more correct sequences on the handwritten CBM ($M = 50.38$, $SD = 18.26$) than on the typed CBM ($M = 41.12$, $SD = 19.17$), $t(51) = -3.67$, $p < 0.01$ (see Table 6).

Posttest Variables. Table 7 displays descriptive statistics for posttest variables (i.e., speed, accuracy, total words, correct sequences) disaggregated by response format (i.e., handwritten, typed). A Dependent Samples t-test revealed no significant difference between student handwriting speed ($M = 14.04$, $SD = 4.12$) and student typing speed ($M = 13.06$, $SD = 4.88$), $t(95) = -1.87$, $p = 0.06$. Students produced a similar amount of characters on the handwriting and the typing speed tests. There was, however, a significant difference in accuracy at posttest. Student accuracy was significantly higher on the handwriting speed test (M

=93.32%, $SD = 9.92$) than on the typing speed test ($M = 90.33\%$, $SD = 11.36$), $t(95) = -2.20$, $p < 0.05$.

At posttest, there was no significant difference between the total number of words produced on the handwritten CBM ($M = 67.18$, $SD = 21.09$) and on the typed CBM ($M = 68.41$, $SD = 25.19$), $t(94) = 0.23$, $p = 0.82$. Students performed similarly on the handwritten CBM and the typed CBM. No significant difference between production on handwritten and typed CBM emerged when data were disaggregated by grade (see Table 6).

There was also no significant difference between story quality on the handwritten CBM ($M = 60.61$, $SD = 21.42$) and on the typed CBM ($M = 63.31$, $SD = 35.34$), $t(94) = 0.98$, $p = 0.33$, at posttest. Students performed similarly on the handwritten CBM and the typed CBM. No significant difference in quality on handwritten and typed CBM emerged when data were disaggregated by grade (see Table 6).

Intervention typing speed. Data were also analyzed within-subjects to examine change in typing speed over time. Weekly typing tests were completed during the 10-week intervention period. The weekly typing test provided progress monitoring data for typing speed (WPM) and accuracy. Overall, students in both treatment groups (i.e., control, intervention) improved their typing speed from week 1 to week 10. Separate Dependent Samples t-test were conducted to examine mean difference between week 1 and week 10 across treatment groups. Students in the control group significantly improved their typing speed from week 1 ($M = 16.40$; $SD = 6.60$) to week 10 ($M = 19.54$; $SD = 6.84$), $t(34) = -5.62$, $p < 0.001$. Similarly, students in the intervention group also significantly improved their typing speed from week 1 ($M = 15.04$; $SD = 5.96$) to week 10 ($M = 20.76$; $SD = 7.19$), $t(50) = -9.18$, $p < 0.001$.

Because student typing speed did improve across the 10-week intervention period, further analyses were conducted to examine changes between pretest and posttest across speed (i.e., typing WPM, handwriting WPM) and writing outcome variables (i.e., TWT, CTS, TWW, CWS). The research questions, addressed below, were designed to examine changes between pretest and posttest across treatment groups.

Research Question 1

Did participation in the typing intervention improve student typing speed (i.e., WPM)? A Mixed Effects ANOVA was used to determine if student typing speed improved following intervention. Student pretest WPM and posttest WPM (within-subject variables) were compared between intervention and control groups (between-subject variables).

The results of the Mixed Effects ANOVA showed no significant interaction between treatment group (i.e., control vs. intervention) and time, $F(1, 96) = 0.031, p = 0.86$ (see Figure 1). There was a significant main effect by Time (i.e., Pretest vs. Posttest), $F(1, 96) = 67.41, p < 0.001$. On average, students improved typing speed from 10.21 WPM ($SD = 4.22$) at pretest to 13.06 WPM ($SD = 4.88$) at posttest. In contrast, there was no significant main effect between treatment groups (i.e., control, intervention), $F(1, 96) = 0.091, p = 0.76$, indicating student typing speed was similar between intervention and control group. Overall, while students did significantly improve typing speed from pretest to posttest, the rate of improvement was similar across both groups (i.e., control, intervention).

Research Question 2

Did participation in the typing intervention influence the discrepancy between handwriting speed (i.e., handwriting WPM) and typing speed (i.e., typing WPM)? A Mixed Effects ANOVA was used to examine how the discrepancy between handwriting speed and

typing speed changed following the intervention. Pretest handwriting speed was subtracted from pretest typing speed to obtain the difference between handwriting speed and typing speed at pretest (i.e., difference in speed at pretest). Posttest handwriting speed was also subtracted from posttest typing speed to obtain the difference between handwriting speed and typing speed at posttest (i.e., difference in speed at posttest). Students' difference in speed at pretest score and students' difference in speed at posttest score (within-subject variables) was compared between intervention and control groups (between-subject variables).

Results of the Mixed Effects ANOVA revealed no significant interaction between the difference in speed at pretest and posttest and treatment group (i.e., control vs. intervention), $F(1, 94) = 0.75$, $p = 0.39$ (see Figure 2). There was not a significant main effect in the difference in speed at pretest ($M = 1.36$, $SD = 5.44$) and the difference in speed at posttest ($M = 0.72$, $SD = 3.74$), $F(1, 94) = 1.06$, $p = 0.31$. At pretest, students' handwriting speed was approximately 1.36 WPM more than their typing speed. At posttest, students' handwriting speed was approximately 0.72 WPM more than their typing speed. Further, there was no significant main effect between treatment groups (i.e., control, intervention), $F(1, 94) = 0.37$, $p = 0.54$.

Research Question 3

Did participation in the typing intervention improve the quality of student typed stories? A Mixed Effects ANOVA was used to determine if student typing quality improved following intervention. Student pretest Correct Typing Sequences (CTS) and posttest CTS (within-subject variables) were compared between intervention and control groups (between-subject variables).

There was not a significant interaction between time and treatment for quality, $F(1, 92) = 1.36$, $p = 0.25$ (see Figure 3). A main effect on quality by time (i.e., pretest, posttest) was found, $F(1, 92) = 152.1$, $p < 0.001$, indicating that typing quality improved, regardless of treatment

group. Descriptive statistics indicated that student typing quality (as measured by correct sequences) did improve from pretest ($M = 39.01$, $SD = 21.64$) to posttest ($M = 62.68$, $SD = 24.41$). There was not, however, a significant main effect on quality by group (i.e., control, intervention), $F(1, 92) = 0.48$, $p = 0.49$, suggesting that improvements in typing quality were similar across treatment groups.

Research Question 4

Did participation in the typing intervention influence the discrepancy between handwritten story quality (i.e., CWS) and typed story quality (i.e., CTS)? A Mixed Effects ANOVA was used to examine how the discrepancy between handwritten story quality and typed story quality changed following the typing intervention. Pretest typing story quality (i.e., CTS) was subtracted from pretest handwritten story quality (i.e., CWS) to obtain the difference between typed story quality and handwritten story quality at pretest (i.e., difference in quality at pretest). Posttest typed story quality (i.e., CTS) was subtracted from posttest handwritten quality (i.e., CWS) to obtain the difference between typed story quality and handwritten story quality posttest (i.e., difference in quality at posttest). Students' difference in quality at pretest score and students' difference in quality at posttest score (within-subject variables) were compared between intervention and control groups (between-subject variables).

There was no significant interaction effect between the difference in quality on handwritten versus typed CBM by treatment group (i.e., intervention vs. control), $F(1, 92) = 0.68$, $p = 0.41$ (see Figure 4). A main effect, however, was found by time, $F(1, 92) = 30.37$, $p < 0.001$. At pretest, students averaged 10.01 ($SD = 19.77$) more correct sequences on their handwritten CBM than on their typed CBM. At posttest, students averaged 1.93 ($SD = 19.95$) fewer correct sequences on their handwritten CBM than on their typed CBM. There was not a

significant main effect by treatment group, $F(1, 92) = 0.004$, $p = 0.95$. Students in the intervention classes averaged 10.11 ($SD = 22.27$) more correct sequences on their handwritten CBM than on their typed CBM at pretest and averaged 2.80 ($SD = 21.01$) fewer correct sequences on their handwritten CBM than on their typed CBM at posttest. Students in the control classes averaged 8.66 ($SD = 15.70$) more correct sequences on their handwritten CBM than on their typed CBM at pretest and averaged 0.90 ($SD = 19.32$) fewer correct sequences on their handwritten CBM than on their typed CBM at posttest.

Research Question 5

Did the typing intervention have social validity for students and/or teachers? Separate researcher-developed social validity surveys were used to collect social validity data from students (Appendix K) and teachers (Appendix L). Results from both student and teacher social validity surveys were examined using descriptive statistics.

Student social validity. Social validity data were collected from 53 students across intervention classrooms at posttest. Each student responded to 12 Likert items on a scale of 1 (*strongly agree*) to 4 (*strongly disagree*). Items were reversed scored so that higher scores indicated a more favorable (i.e., strongly agree) view of the intervention. Thus, positively worded items were reversed scored. Item means and standard deviations can be found in Table 8. Across the 12 items, the average response was 2.68 ($SD = 0.35$). Responses to specific items showed that many agreed or strongly agreed that the typing activities (lessons and games) made them better at typing a story on the computer ($M = 3.19$; $SD = 0.92$). Additionally, many students agreed or strongly agreed with the statement, *I liked the typing games* ($M = 3.15$; $SD = 1.00$).

Teacher social validity. Social validity data were collected from all four intervention classroom teachers. Each teacher responded to 10 Likert items on a scale of 1 (*strongly*

disagree) to 5 (*strongly agree*). Item means and standard deviations can be found in Table 9. Across the 10 items, the average response was 3.83 ($SD = 0.83$). Responses to specific items showed that teachers either agreed or strongly agreed with the following statements: *I liked having my students visit www.typing.com each week* ($M = 4.25$; $SD = 0.5$), *I think the typing lessons improved my students' typing skills* ($M = 4.25$; $SD = 0.5$), *I think the typing games were engaging* ($M = 4.5$; $SD = 0.58$), and *I think the typing games improved my students' typing skills* ($M = 4.25$; $SD = 0.5$). Further, all teachers agreed that they would recommend the intervention to a fellow teacher.

Exploratory Analyses

Because absenteeism and student engagement were a factor in this intervention, researchers decided to further examine results while controlling for the number of lessons completed. It was assumed that students who attended class and engaged in the intervention would complete more typing lessons than students who were absent/not engaged. It was further assumed that students who completed more typing lessons would reap more direct benefit from the intervention.

Data on the number of lessons completed was obtained from www.typing.com for each student in the intervention classroom. Initial bivariate correlations were conducted with the intervention group to examine the relationship between the number of lessons completed and posttest typing outcomes (i.e., typing speed, typing accuracy, TWT, CTS). Results were mixed; a moderate positive relationship was found between the number of lessons completed and posttest TWT, posttest CTS, and posttest typing speed. No significant relationship was found between the number of lessons completed and typing accuracy at posttest (see Table 10). Based on the significant findings, further bivariate correlations were conducted with the intervention

group examining the change in typing outcome variables (e.g., the number of words typed at pretest subtracted from the number of words typed at posttest) and number of lessons completed. A weak positive relationship was found between the number of lessons completed and difference in typing speed at pretest and posttest, $r(54) = 0.304$, $p = 0.02$, $r^2 = .09$. No other relationships examined were significant (see Table 11). Because additional relationships were not significant, no further analyses were conducted.

CHAPTER IV

Discussion

Despite recent evidence suggesting that elementary school students may not possess the typing skills necessary to produce quality typed compositions (Chwat, 2017; White et al., 2015), students are still expected to demonstrate their writing skills in a computerized format. The current study evaluated the effects of a typing intervention designed to improve typing speed. Analysis of within-subject (i.e., pretest, posttest) and between-subject (i.e., control, intervention) data revealed mixed results. Within-subject analyses revealed that student typing speed, typing production, and typing quality improved from pretest to posttest. No significant difference, however, emerged between groups (i.e., intervention, control), suggesting that the intervention was ineffective across the 10-week period. Similar results were found when examining the difference between typing and handwriting skills. Differences emerged by time, but not by group. Although no significant results were found between groups, the intervention did have high social validity for both teachers and students.

Further, due to absenteeism and varying levels of student engagement, students in the intervention group did not necessarily receive the same dosage of the intervention. Thus, researchers further examined intervention effectiveness while examining the relationship between the number of lessons completed and typing outcomes. It was assumed that students who attended class and actively participated in the intervention would complete more lessons on www.typing.com. A significant moderate positive relationship was found between the number of lessons completed and posttest TWT, posttest CTS, and posttest typing speed; however, no significant relationship was found between the number of lessons completed and typing accuracy at posttest. Further bivariate correlations examining the *change* in typing outcome variables

(e.g., the number of words typed at pretest subtracted from the number of words typed at posttest) and number of lessons completed revealed mixed results. A significant weak positive relationship was found between the number of lessons completed and change in typing speed; however, no significant relationships were found. Thus, the number of lessons completed did not appear to significantly impact student typing outcomes.

Examination of Typing Outcomes

It was hypothesized that participation in a 10-week typing intervention would improve student typing speed and lead to improvements in typing outcomes (WPM, quality). Results revealed that student typing speed did improve over the 10-week intervention period; however, typing speed improved across both the intervention and control groups. Similar results were found for typed story quality. The quality of students' typed story improved from pretest to posttest; however, improvements were observed across both the intervention and control group. Results of separate Mixed Effects ANOVA revealed no interactions effects – indicating that the rate of improvement in typing speed (WPM) and typing quality (correct typing sequences) was similar across both intervention and control groups. Because no difference emerged by group, it is unclear what effect the 10-week typing intervention had on typing outcome variables. It is possible that the length of the intervention was too short and more notable effects would have been observed if the intervention was lengthened. With current results, no definitive conclusions can be drawn about the effectiveness of the 10-week typing intervention.

Examination of Difference between Handwritten and Typed Stories

It was hypothesized that participation the 10-week typing intervention would decrease the discrepancy between handwriting speed and typing speed. Specifically, it was hypothesized that students' handwriting speed would be higher than student typing speed prior to intervention, but

students' typing speed would approach, or exceed, handwriting speed following intervention. This hypothesis was grounded in previous research suggesting that student typing speed typically does not exceed handwriting speed until students are 14- years old (i.e., 8th grade; Horne et al., 2011) as well as research findings suggesting that eighth-grade students' (i.e., 14-years old) writing performance was similar across computer- and paper-based assessments (Horkay, et al., 2006; White et al., 2015).

Results supported these hypotheses; students' handwriting speed was significantly higher than typing speed at pretest. At posttest, typing speed approached handwriting speed and no significant difference in speed emerged. Thus, results supported the initial hypothesis; however, no significant difference emerged by time or group for typing speed, indicating that while students did improve their typing speed over time, the increase was not statistically significant.

Although no significant differences emerged by time or group (i.e., control, intervention), results do support previous research suggesting that students need to type as quickly as they handwrite to compose similar typed and handwritten compositions (Balajthy, 1988). Additionally, results of the current study are in line with previous research findings that student performance on handwritten compositions often exceeds performance on typed compositions (Chwat, 2017; White et al., 2015). In the current study, students in the fourth- and fifth-grade produced significantly more words and significantly more correct sequences in a handwritten format than in a typing format at pretest. Further, at pretest, student handwriting speed was significantly higher than student typing speed. Thus, it could be argued that the time of pretest, students could not demonstrate their writing skills using a computerized format.

Alternatively, at posttest, no differences emerged by format (i.e., handwriting, typing). Students produced a similar number of words and correct sequences in both formats. Further,

handwriting speed was similar to student typing speed. These results, in conjunction with results from pretest, support the notion that students should type as quickly as they handwrite to create comparable compositions in typed and handwritten format. At pretest, student typing speed was significantly lower than student handwriting speed. As a result, students produced significantly more words and more correct sequences on handwritten compositions than on typed compositions. At posttest, handwriting speed and typing speed were comparable. As a result, words produced and correct sequences were similar across formats.

In regard to differences in quality of handwriting and typing speed, a similar hypothesis was proposed. It was hypothesized that participation in the 10-week typing intervention would decrease the discrepancy between handwriting speed and typing quality. Specifically, handwriting quality would be higher than typing quality at pretest, but typing quality would approach, or exceed, handwriting quality at posttest. While the results of the Mixed Effects ANOVA did not reveal a significant interaction effect, a main effect was observed by time. As hypothesized, at pretest, students in both groups produced higher quality handwritten stories than typed stories. The opposite was true at posttest. Students produced higher quality typed stories than handwritten stories. This difference was significant, indicating that the quality of typed stories was greater at posttest than at pretest; however, there was no difference between groups.

Limitations and Future Research

Additional research designed to address limitations of the current study is needed. First, students in the control group completed weekly typing test. Students were provided feedback via www.typing.com about their typing speed. Thus, a practice effect may have occurred. Further, the weekly tests may have been motivational and acted as a “mini” intervention for students. In addition, the intervention was implemented by classroom teachers and participation was not

required. Students could progress through the lessons at their own pace. Thus, students may not have actively participated in the typing intervention during each of the weekly sessions across the intervention period. Absenteeism was a factor, as students were not required to make-up a weekly session if missed. Even students who were in attendance were not required to engage or remain on task. Further, intervention sessions often took place during the students' physical activity time – a time when students typically were allowed recess or free time. Thus, students in the intervention classrooms engaged in the typing intervention while students in the control classrooms were allowed their typical physical activity time. Students were aware that they were engaging in the intervention while their peers had free time. Researchers attempted to control for absenteeism and engagement by examining the number of lessons completed and the number of typing tests completed; however, future researchers should consider making the intervention a requirement or by assigning a grade based on participation. Additionally, future researchers should find an appropriate time to complete intervention sessions when students do not feel they are missing out on a preferred activity. It might be beneficial to incorporate a behavioral component (e.g., reinforcement for lesson completion) with the intervention to ensure students are engaged.

The length of the typing intervention for the current study was determined by the school calendar. A 10-week intervention period was selected because that was the length of time between when the intervention began and Thanksgiving break. Thus, it is possible that the length of the intervention was too short and more notable effects would have been observed if the intervention was lengthened. With current results, no definitive conclusions can be drawn about the effectiveness of the 10-week typing intervention. As typing is a skill that is likely to improve with practice (Gast & Hammond, 2010), future researchers should consider conducting

longitudinal studies designed to determine if direct typing interventions designed to improve typing speed enhance typed writing outcomes over time. Variations in the length of the intervention, as well as the length of sessions (e.g., 10 minutes, 3 times per week) should be examined to find an optimal intervention length.

Students in both intervention and control classrooms participated in a technology class at their school for approximately 45 min per week. The weekly class provided digital literacy instruction (e.g., instruction in the use of word processing software), direct instruction on typing, and repeated practice of typing skills. The technology instructor encouraged students to practice their skills at home. Thus, it is unknown which students engaged in typing practice at home at the request of their technology instructor.

While acknowledging limitations associated with the current study, future research is needed to examine the relationship between typing speed and typed writing outcomes. Future researchers should seek to determine the effectiveness of a typing intervention using www.typing.com and investigate an optimal intervention time frame. Based on the results of the current study, students were performing similarly (e.g., production, quality) at posttest on handwritten and typed stories. If future research indicates that students are performing equivocal on handwritten and typed assignments, the use of computer-based assessments for writing may be a valid option. Further research is needed to determine if students across schools and grade levels are performing similarly on typed and handwritten assignments. It is possible that differences between intervention and control classrooms would emerge if a similar intervention were implemented with younger students. Graham et al. (2012) suggested that students should begin typing instruction in the first-grade. Thus, younger students may receive more benefit from a similar typing intervention.

Implications and Summary

Overall, results of the current study revealed mixed results. Student typing speed, as well as typed writing outcomes, increased over the 10-week intervention period; however, no differences emerged by group. Thus, it is unclear if differences emerged due to typical maturation, or if an unidentified variable caused changes in typing speed and typed writing outcomes. While results were unclear, exploratory analyses revealed an insignificant relationship between the number of typing lessons completed and most typing outcome variables (i.e., typing accuracy, total words typed, correct typing sequences). A weak positive relationship was found between the number of lessons completed and the change in typing speed (i.e., speed at pretest subtracted from speed at posttest). While results were mixed, the current student continues to support the need for typing interventions designed to improve typing skills.

Additionally, results of the current study support previous research suggesting that students need to type as quickly as they handwrite to compose similar compositions in typed and handwritten formats (Balajthy, 1988). At pretest, student handwriting speed was significantly higher than typing speed. As a result, students produced more words and more correct sequences in the handwritten format than in the typed format. At posttest, no differences emerged. Student handwriting speed and typing speed were similar; students produced a similar number of words and correct sequences across formats.

These results underscore the continued need to focus on developing student typing skills. Students do need to be able to type as quickly as they handwrite to produce similar compositions in typed and handwritten formats. Thus, interventions designed to improve typing speed should be further investigated. In conclusion, while the current typing intervention did not produce significant group differences (i.e., control, interventions), student typing skills did significantly

improve from pretest to posttest. With improvements in typing speed, improvements in typed writing outcomes were also found.

REFERENCES

- Achieve, Inc. (2005). *Rising to the challenge: Are high school graduate prepared for college and work?* Washington, DC: Author.
- Aguinis, H., Gottfredson, R. K., & Joo, H. (2013). Best-practice recommendations for defining, identifying, and handling outliers. *Organizational Research Methods*, 0, 1-32.
- Balajthy, E. (1988). Keyboarding, language arts and the elementary school child. *Computing Teacher*, 15, 40-43.
- Berninger, V. W., Vaughan, K. B., Abbott, R. D., Abbott, S. P., Rogan, L. W., Brooks, A...
Graham, S. (1997). Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. *Journal of Educational Psychology*, 89:4, 652-666.
- Berninger, V., & Amtmann, D. (2003). Preventing written expression disabilities through early continuing assessment and intervention for handwriting and/or spelling problems: Research and into practice. In H. L. Swanson, K. Harris, & S. Graham (Eds.), *Handbook of Research on Learning Disabilities* (pp. 345–363). New York, NY: Guilford.
- Berninger, V. W., Rutberg, J. E., Abbott, R. D., Garcia, N., Anderson-Youngstrom, M., Brooks, A. & Fulton, C. (2006). Tier 1 and tier 2 early intervention for handwriting and composing. *Journal of School Psychology*, 44, 3-30.
- Berninger, V.W., Vaughan, K., Abbott, R.D., Begay, K., Coleman, K.B., Curtin, G., Hawkins, J.M. & Graham, S.G. (2002). Teaching spelling and composition alone and together: Implications for the simple view of writing. *Journal of Educational Psychology*, 94, 291-304.
- Bourdin, B., & Fayol, M. (2000). Is graphic activity cognitively costly? A developmental approach. *Reading and Writing*, 13, 183-196.

- Chen, J., White, S., McCloskey, M., Soroui, J., & Chen, Y. (2011). Effects of computer versus paper administration of adult functional writing assessment. *Assessing Writing*, 16, 49-71.
- Christensen, C. A. (2004). Relationship between orthographic-motor integration and computer use for the production of creative and well-structured written text. *British Journal of Educational Psychology*, 74, 551–565.
- Chwat, C (2017). The impact of technology access, attitudes, and use on student typing and writing performance. (Unpublished Doctoral Dissertation). University of Tennessee, Knoxville, TN.
- Common Core State Standards Initiative: Preparing America’s Students for College and Career. (2018). Retrieved from: <http://www.corestandards.org>.
- Connelly, V., Gee, D., & Walsh, E. (2007). A comparison of keyboarded and handwritten compositions and the relationship with transcription speed. *British Journal of Educational Psychology*, 77, 479-492.
- Cutler, L. & Graham, S. (2008). Primary grade writing instruction: A national survey. *Journal of Educational Psychology*, 100, 907-919.
- Deane, P., Odendahl, N., Quinlan, T., Fowles, M., Welsh, C., & Bivens-Tatum, J. (2008). Cognitive models of writing: Writing proficiency as a complex integrated skill. Princeton: NJ.
- Fink, J. L.W. (2016). Common Core assessments: The inside scoop on the PARCC and smarter balanced assessments. Retrieved from: <https://www.scholastic.com/teachers/articles/teaching-content/common-core-assessments/>.

- Flower, L. & Hayes, J. R. (1981). A cognitive process theory of writing. *College Composition and Communication*, 32, 365-387.
- Gansle, K. A., VanDerHeyden, A. M., Noell, G. H., Resetar, J. L. & Williams, K. L. (2006). The technical adequacy of curriculum-based and rating-based measures of written expression for elementary school students. *School Psychology Review*, 35, 435-450.
- Gilbert, J., & Graham, S. (2010). Teaching writing to elementary students in grades 4 to 6: A national survey. *Elementary School Journal*, 110, 494 –518.
- Graham, S. (2008). *Effective writing instruction for all students*. Retrieved January 10, 2018 from <http://www.renaissance.com/Resources/Research>.
- Graham, S., Bollinger, A., Booth Olson, C., D'Aoust, C., MacArthur, C., McCutchen, D., & Olinghouse, N. G. (2012). *Teaching elementary school students to be effective writers: A practice guide* (NCEE 2012-4058). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/wwc/publications_reviews.aspx#pubsearch
- Graham, S., Capizzi, A., Harris, K. R., Hebert, M., & Morphy, P. (2014). Teaching writing to middle school students: A national survey. *Reading and Writing*, 27, 1015-1042.
- Graham, S. & Harris, K. R. (2015). Common core state standards and writing. *The Elementary School Journal*, 115, 457-463.
- Graham, S., Harris, K., & Santangelo, T. (2015). Research-based writing practices and the common core: Meta-analysis and meta-synthesis, *The Elementary School Journal*, 115, 498-522.

- Graham, S., McKeown, D., Kiuahara, S., & Harris, K. R. (2012). A meta-analysis of writing instruction for students in the elementary grades. *Journal of Educational Psychology*, 104, 879-896.
- Graham, S., & Perin, D. (2007). A meta-analysis of writing instruction for adolescent students. *Journal of Educational Psychology*, 99, 445–476.
- Haring, N. G., & Eaton, M.D. (1978). Systematic instructional procedures: An instructional hierarchy. In N. G. Haring, T. C. Lovitt, M.D. Eaton & C. L. Hansen (Eds.), *The fourth R: Research in the classroom* (pp. 23-40). Columbus, OH: Merrill.
- Hayes, J. R. (2009). From idea to text. In D. Myhill (Eds.). *Handbook of writing development* (pp. 65-79). London, England: Sage.
- Hayes, R., & Olinghous, N. G. (2015). Can cognitive writing models inform the design of the common core state standards? *The Elementary School Journal*, 115, 480-498.
- Horkay, N., Bennett, R. E., Allen, N., Kaplan, B., & Yan, F. (2006). Does it matter if I take my writing test on computer? An empirical study of mode effects in NAEP. *The Journal of Technology, Learning, and Assessment*, 5. Retrieved February 2018 from <http://www.jtla.org>.
- Horne, J., Ferrier, J., Singleton, C., & Read, C. (2011). Computerised assessment of handwriting and typing speed. *Educational and Child Psychology*, 28, 52-66
- Jewell, J. & Malecki, C. K. (2005). The utility of CBM written language indices: An investigation of production-dependent, production-independent, and accurate-production scores. *School Psychology Review*, 34, 27-44.
- Jones, I. (1994). The effect of the word processor on the written composition of second-grade pupils. *Computers in the Schools*, 11, 43–54.

- Jones, D. & Christensen, C. A. (1999). Relationship between automaticity in handwriting and students' ability to generate written text. *Journal of Educational Psychology*, 91, 44–49.
- Kellogg, R. & Whiteford A. (2009). Training advanced writing skills: The case for deliberate practice. *Educational Psychologist*, 44, 250-266.
- Klein, S., Guiltner, V., Sollereeder, P., & Cui, Y. (2011). Relationships between fine-motor, visual-motor, and visual perception scores and handwritten legibility and speed. *Physical and Occupational Therapy in Pediatrics*, 31:1, 103-114.
- Kline, R.B. (2005). *Principles and Practice of Structural Equation Modeling* (2nd Edition ed.). New York: The Guilford Press.
- McLaughlin, T. F., & Skinner, C. H. (1996). Improving academic performance through self-management: Cover, copy, and compare. *Intervention in School & Clinic*, 32, 113.
- McMaster, K. L. & Campbell, H. (2008). New and existing curriculum-based writing measures: Technical features within and across grades. *School Psychology Review*, 37, 550-566.
- McMaster, K. L., Du, X. & Petursdottir, A. (2009). Technical features of curriculum-based measures for beginning writers. *Journal of Learning Disabilities*, 42, 41-60.
- Morrow, J. A. & Skolits, G. (2015). Twelve Steps of Quantitative Data Cleaning: Strategies for Dealing with Dirty Evaluation Data. Presentation presented at the American Evaluation Association Conference in 2015.
- National Center for Education Statistics (2012). The Nation's Report Card: Writing 2011 (NCES 2012–470). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.
- National Commission on Writing in America's Schools and Colleges. (2004). *Writing: A ticket to work . . . or a ticket out*. New York: College Board.

- National Commission on Writing in America's Schools and Colleges. (2006). *Writing and school reform*. New York: College Board.
- Nies, K. A., & Belfiore, P. J. (2006). Enhancing spelling performance in students with learning disabilities. *Journal of Behavioral Education, 15*, 162-169.
- Persky, H. R., Daane, M. C., & Jin, Y. (2003). *The nation's report card: Writing 2002*. (NCES 2003-529). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics.
- Poncy, B. C., Skinner, C. H., & Jaspers, K. E. (2007). Evaluating and comparing interventions designed to enhance math fact accuracy and fluency: Cover, copy, and compare versus taped problems. *Journal of Behavioral Education, 16*, 27-37.
- Porter, A., McMaken, J., Hwang, J., & Yang, R. (2011). Common core standards the new US intended curriculum. *Educational Researcher, 40*, 103-116.
- Powell-Smith, K. A. & Shinn, M. R. (2004). Administration and scoring of written expression curriculum-based measurement (WE-CBM) for use in general outcome measurement. *Training Workbook*. Retrieved December 18, 2017 from: <https://www.aimsweb.com/wp-content/uploads/written-expression-cbm-manual.pdf>.
- Rogers, J. & Case-Smith, J. (2002). Relationships between handwriting and keyboarding performance of sixth-grade students. *American Journal of Occupational Therapy, 56*, 34-39.
- Salahu-Din, D., Persky, H., & Miller, J. (2008). *The Nation's Report Card: Writing 2007* (NCES 2008-468). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

- Sanoff, A. P. (2006). A perception gap over students' preparation. *Chronicle of Higher Education*, 52, B9-B14.
- Shanahan, T. (2015). Common core state standards: A new role for writing. *The Elementary School Journal*, 115, 464-479.
- Skinner C.H. (1998) Preventing Academic Skills Deficits. In: Watson T.S., Gresham F.M. (eds) *Handbook of Child Behavior Therapy. Issues in Clinical Child Psychology*. Springer, Boston, MA.
- Slavin, R., Madden, N., & Karweit, N. (1989). Effective programs for students at-risk: Conclusions for practice and policy. In R. Slavin, N. Karweit, & N. Madden (Eds.), *Effective programs for students at-risk* (pp. 21–54). Boston, MA: Allyn & Bacon.
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Pearson and Allyn & Bacon.
- U.S. Department of Education. (2003). Institute of Education Sciences. National Center for Education Statistics. The Nation's Report Card: Writing 2002, NCES 2003–529, by H. R. Persky, M. C. Daane, and Y. Jin. Washington, D.C.
- Wanzek, J., Vaughn, S., Wexler, J., Swanson, E. A., Edmonds, M., & Kim, A. (2006). A synthesis of spelling and reading interventions and their effects on the spelling outcomes of students with LD. *Journal of Learning Disabilities*, 39, 528-543.
- White, S., Kim, Y., Chen, J., and Liu, F. (2015). Performance of fourth-grade students in the 2012 NAEP computer-based writing pilot assessment: Scores, text length, and use of editing tools (NCES 2015-119). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Wolfe, E., & Manalo, J. R. (2004). Composition medium comparability in a direct writing assessment of non-native English speakers. *Language, Learning, and Technology*, 8, 53-65.

Wright, J. (2003). How To: Match the Student to the Right Academic Intervention with the Instructional Hierarchy. Retrieved August 21, 2015, from http://www.interventioncentral.org/instruction_instructional_hierarchy.

APPENDICES

Appendix A

Teacher Informed Consent

Student Typing Instruction
Informed Teacher Consent Form

You are invited to be part of a research study being conducted Stephanie Daniels, M.S. and Merilee McCurdy, Ph.D. at the University of Tennessee, Knoxville. You are being invited because your classroom will participate in a typing instruction program this year at Newport Grammar School. Being in this research study is voluntary, and you should only agree if you completely understand the study and want to volunteer your material and your students' material to be used. This form contains information that will help you decide if you want to be part of this research study or not. Please take the time to read it carefully, and if there is anything you don't understand, please ask questions.

Purpose

The purpose of this study is to investigate the effectiveness of a typing instruction program designed to improve student typing speed. We plan to publish articles and make presentations at conferences to share the results of this research.

Participation

If you choose to participate, we will analyze the materials you and your students create during your time involved in the typing instruction program. Materials include: Procedural integrity data collected by researchers (a checklist ensure all procedures are being followed as intended) and a social validity survey completed at the end of the program to let us know what you thought about it/if you feel it was helpful to your students. Because these are all things that are part of your regular program evaluation activity for the typing instruction program, being included in the research will not require any additional time.

Benefit

You will not receive any direct benefit from allowing your materials to be used in the research project, but we hope to learn things that will benefit teachers and researchers in the future.

Risks

This research is considered to be no more than minimal risk, which means there is no more expected risk to you than what you might experience during a typical day. There is the risk of possible loss of confidentiality, as someone could find out you were in the study or see your study information, but we believe that risk is unlikely because of the procedures we will use to protect your information.

Confidentiality

If you agree to allow your materials to be used in the research, we will assign you a code number and use that instead of your name on all of the materials before we begin analyzing them for the research study. These materials will be stored in a secure location on the UT campus and all data files will be password protected and securely stored. No information which could identify you or your students will be shared in publications and presentations about this study.

Future Research

Your materials may be used for future research studies or shared with other researchers for use in future studies without obtaining additional informed consent from you. If this happens, all of your identifiable information will be removed before any future use or sharing with other researchers.

Contact Information

If you have any questions about this research, please contact me, Stephanie Daniels, at skdan@vols.utk.edu or my advisor, Merilee McCurdy, at mccurdy2@utk.edu or 865-974-8144. If you have any questions about your rights as a research participant, please contact the Institutional Review

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Board (IRB) of the University of Tennessee, Knoxville, at utkirb@utk.edu or 865-974-7697. You may also contact the IRB with any problems, complaints or concerns you have about a research study.

Voluntary Participation

It is completely up to you to decide to be in this research study. Even if you decide to be part of the study now, you may change your mind at any time by alerting the primary researcher of your desire to withdraw from the study. You will not lose any services, benefits, or rights you would normally have if you choose not to volunteer, or if you change your mind and stop being in the study later. If you do not wish to be in the research, it is not necessary to do anything, as we cannot use your materials without your consent.

Consent

I have read the above information. I have received a copy of this form. I understand that my participation in this research study includes allowing Stephanie Daniels and Merilee McCurdy to use my materials for research purposes. I agree to be included in this study.

Participant's Name (printed) _____

Participant's Signature _____ Date _____

IRB NUMBER: UTK IRB-18-04538-XP
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IRB EXPIRATION DATE: 08/13/2019

Appendix B

Parent Permission and Youth Assent

Student Typing Instruction Parent Permission Form

Your child is invited to be part of a research study being conducted by Stephanie Daniels, M.S. and Merilee McCurdy, Ph.D. at the University of Tennessee, Knoxville. Your child is being invited because he/she will participate in a typing instruction program this year at Newport Grammar School. Being in this research study is voluntary, and you should only agree if you completely understand the study and want to volunteer to allow your child's material to be used. This form contains information that will help you decide if you want your child to be part of this research study or not. Please take the time to read it carefully, and if there is anything you do not understand, please ask questions.

Purpose

The purpose of this study is to investigate the effectiveness of a typing instruction program designed to improve student typing speed. We plan to publish articles and make presentations at conferences to share the results of this research.

Participation

If you choose to allow your child to participate and your child also agrees, we will analyze the materials your child will create during their time involved in the typing instruction program as well as pre- and post-surveys they complete to tell us what they thought about it/what they learned. Because these are all things that will be part of their regular classroom activities, participation in the research will not require any additional time.

Benefit

Your child will not receive any direct benefit from allowing their materials to be used in the research project, but we hope to learn things that will benefit teachers and researchers in the future.

Risks

This research is considered to be no more than minimal risk, which means there is no more expected risk to you than what your child might experience during a typical day. There is the risk of possible loss of confidentiality, as someone could find out your child was in the study or see their study information, but we believe that risk is unlikely because of the procedures we will use to protect their information.

Confidentiality

If you and your child agree to participate in the research, we will assign your child a code number and use that instead of their name on all of the materials before we begin analyzing them for the research study. These materials will be stored in a secure location on the UT campus and all data files will be password protected and securely stored. No information which could identify your child will be shared in publications and presentations about this study.

Future Research

Your child's materials may be used for future research studies or shared with other researchers for use in future studies without obtaining additional informed consent from you. If this happens, all of your child's identifiable information will be removed before any future use or sharing with other researchers.

Contact Information

If you have any questions about this research, please contact me, Stephanie Daniels, at skdan@vols.utk.edu or my advisor, Merilee McCurdy, at mccurdy2@utk.edu or 865-974-8144. If you have any questions about your rights as a research participant, please contact the Institutional Review Board (IRB) of the University of Tennessee, Knoxville, at utkirb@utk.edu or 865-974-7697. You may also contact the IRB with any problems, complaints or concerns you have about a research study.

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Voluntary Participation

It is completely up to you and your child to decide to be in this research study. Even if you decide to be part of the study now, you may change your mind at any time and stop participating by informing your child's teacher that you no longer wish to participate. Your child will not lose any services, benefits, or rights they would normally have if you choose not to give permission, or if you or your child change your minds and stop participating later.

If you agree that your child may participate, please print and sign the **Parent Permission** section below, and have your child sign the **Assent** section, on both copies of this form. Return one copy to your child's classroom teacher and keep one copy for your records. If you do not wish for your child to participate in the research, it is not necessary to do anything, as we cannot use their materials without your permission and your child's assent.

Parent Permission

I have read the above information. I have received a copy of this form. I understand that my child's participation in this research study includes allowing Stephanie Daniels and Merilee McCurdy to use my child's materials for research purposes. I agree that my child may participate in this study.

Child's Name (printed) _____

Parent's Name (printed) _____

Parent's Signature _____ Date _____

Child/Youth Assent

I have talked about this research with my parent(s) and I agree that Stephanie Daniels and Merilee McCurdy may use my materials for research purposes. If I change my mind, and decide not to participate later, I only need to let my classroom teacher know.

Youth Name (printed) _____

Youth Signature _____ Date _____

IRB NUMBER: UTK IRB-18-04538-XP
IRB APPROVAL DATE: 08/14/2018
IRB EXPIRATION DATE: 08/13/2019

Appendix C

Example Research Packet

Research Packet Page 1

Name: _____

username: **00185**

Password: **typing**

Handwriting Speed Prompt

The quick brown fox jumps over the lazy dog. Brown dog fox lazy the over the quick jumps. The quick the fox over brown jumps lazy dog. The the over dog brown fox lazy jumps quick. Over the fox the jumps quick lazy brown dog. Lazy dog quick brown the fox jumps the over. The dog the brown over lazy jumps fox quick. Fox dog the lazy over jumps the brown quick. Dog quick brown over the jumps the fox lazy.

Dog jumps quick brown fox over the lazy the. Lazy brown jumps fox over the quick the dog. The lazy the dog brown quick fox over jumps. Brown the quick dog jumps fox lazy the over. Quick dog lazy jumps the over the brown fox. Dog the over the lazy jumps fox quick brown. The brown the dog over lazy jumps fox quick. Brown over dog quick lazy the jumps the fox. Fox the lazy dog the jumps brown quick over.

the. Jumps quick fox over the lazy dog the brown. The quick jumps dog the over brown lazy
fox. The lazy brown dog jumps over the quick fox. Jumps brown lazy dog the quick fox the
over. Fox brown over jumps lazy the dog the quick.

Appendix D

Sample Pretest Administration Script

1. Ask students to log onto their computer and open the internet browser.
2. As students are logging onto their computer, pass out research packets. Tell the students Leave this facedown until we tell you to do otherwise.
3. Once all students have logged onto their computer, opened the internet browser, and have a study packet say Hi, we are (introduce researchers) and we are from UT. We are here today because we need your help with a project. Everyone in the class is going to participate. We are here today to get started.
4. Today we will be doing some typing and handwriting. We have 5 things for you to do today: 1) a handwriting test, 2) a typing test, 3) a handwritten story, 4) a typed story, and lastly 5) some questions about you. We are going to go through everything together. But if you have any questions throughout just raise your hand. Are there any questions before we begin?
5. We are going to start with a handwriting test. We will get to the stuff on the computer in a bit. But for now, push your laptop aside. Turn over the paper on your desk. The paper should have a sticky note with your name on it and your lunch number should be on the first page. We will remove the sticky note before we leave, so your name will not be on any of the work you do today.
6. Go ahead and turn to the second page. You should be looking at a blank page with some lines on it. We are going to pass out a piece of paper with some sentences on it. Some of the sentences will make sense, others of them will not. When I say go, I want you to copy each sentence from our paper onto your paper. I want you to write as quickly as you can without making mistakes. Make sure you copy each sentence exactly as it is printed on the paper we are passing out. Are there any questions?
7. Instruct students to turn to handwriting speed test prompt. When everyone has the handwriting speed test prompt say, When I say go, you will have 2 minutes to write as many of these sentences as you can. Are there any questions?
8. You may begin!
9. Start timer. At 2-min say, Stop! Put your pencils down and turn back to the first page of your packet.
10. Now we are going to do a few things on the computer. You should have the internet browser open. Please go to the Newport Home Page and click on Useful Links on the side. Scroll all the way to the bottom. Under the technology heading you should see a link that says typing study. Please click that. It should take you to a new webpage. Make sure everyone is on the Online survey.
11. Once you've clicked the link you should be on a page that says, thank you for helping us with our study! Today, we will ask you to do some writing and typing. You will also answer a few questions about yourself. If you have any questions throughout, please raise your hand and someone will come help you. When you are ready to begin, press the arrow button. Everyone press arrow button.
12. Now, this page says please enter your ID number on the front of your packet. Once you have correctly entered your ID number press the arrow button.

13. Please re-enter your ID number. If you forget, it is listed on the front of your packet. Press the arrow button when you are done. Make sure you enter your ID number correctly, it is really important!
14. On the next page, click the box next to number one then press the arrow button.
15. Now we are going to typing speed test. We are going to pass out a piece of paper with some different sentences on it. Some of the sentences will make sense, others of them will not. When I say go, I want you to type each sentence from our paper on this screen. I want you to type as quickly as you can without making mistakes. Make sure you type each sentence exactly as it is printed on the paper we are going to pass out. Are there any questions?
16. Instruct students to turn to the correct page of their study packet. Ensure that students do not start typing. When I say go, you will have 2 minutes to type as many of these sentences as you can. Are there any questions?
17. You may begin!
18. Begin timer. After 2 minutes say, Stop! Click the arrow button.
19. Ensure all students click the button. Great job! Now we are going to write a few stories. When everyone is ready tell the students, Click the arrow button.
20. For this, we are going to write a story. Push your laptop aside so you have room to write. I want you to hand write a story. I am going to read the first few words of the story to you then I want you to write a story about what happens next. You will have 1 minute to think about the story you will write, and then you'll have 5 minutes to write it. Do your best work. If you don't know how to spell a word, you should guess. You can use the words typed on the top of the page as the first part of your sentence. If you have any questions, raise your hand and someone will come help you. Are there any questions now? In the middle of the story, I am going to ask you to circle the last word or punctuation mark you wrote. When I say that, I just want you to circle whatever you wrote and then keep writing. Are there any questions? Press the arrow button and turn to the last page of your study packet.
21. For the next minute, you should be thinking about 'my favorite game is ...'
22. Begin timing. If students start writing, instruct them to wait until you tell them to begin writing.
23. After 30 seconds say, you should be thinking about your 'favorite game'.
24. After 1 minute, say, Start Writing. (Restart the stop watch.) Walk around the classroom to ensure the students are writing. As students are writing, walk around and advance their surveys to the screen that says, "You may start writing."
25. After 90 seconds, say, You should be writing about 'your 'favorite game'.
26. At 3 minutes, say please circle the last word or punctuation mark you wrote and keep writing.
27. At five minutes say, Stop and put your pencil down. Go ahead and turn your paper over. Put it face down. Make sure everyone finishes their story and turns over their paper. When everything is completed say Press the arrow button.
28. Now I want you to type a story. I am going to read the first few words of the story to you then I want you to type a story about what happens next. You will have 1 minute to think about the story you will write, and then you'll have 5 minutes to type it. Do your best work. If you don't know how to spell a word, you should guess. You can use the words typed at the top of the next screen as the first part of your sentence. If you have any questions, raise your hand and someone will come help you. Are there any questions? This time, in the middle, I am going to ask you type 3 "x's". When I say that, I want you to type the letter "x" three times, then keep typing. Are there any questions?

29. Okay, press the arrow button. For the next minute, you should be thinking about your 'favorite T.V. Show'...
30. Begin timing. If students start writing, instruct them to wait until you tell them to begin writing.
31. After 30 seconds say, you should be thinking about your 'favorite T.V. Show'...
32. After 1 minute, say, Start Writing. (Restart the stop watch.) Walk around the classroom to ensure the students are writing.
33. After 90 seconds, say, you should be writing about your 'favorite T.V. Show'...
34. At five minutes say, Stop typing and press the arrow button. Make sure everyone moves on to next page. Say Now we want you to answer a few questions about yourself! If you have any questions or need something explained, just raise your hand and someone will come help you.
35. Read demographic questions.

Appendix E

Teacher Intervention Script

Intervention Classroom – Typing Lesson Days		✓
1.	Instruct students to go to typing.com and enter their username and password	
2.	Say, “Today is a typing lesson day. Click the Lessons button at the top of the page and continue your lessons.”	
3.	Allow students 10 minutes to engage in the typing lessons.	
4.	Monitor the room to ensure students are not playing games.	
5.	After 10 minutes, say “Stop, log-off the typing.com website.”	

Intervention Classroom – Typing Games/Test Day		✓
1.	Instruct students to go to typing.com and enter their username and password	
2.	Say, “Today is a typing game/test day. Click the Games button at the top of the page and play any of the games on the page.”	
3.	Allow students 9 minutes to engage in the typing games.	
4.	Say, “Now it’s time to take your typing test. Everyone quit your game and click the Test button at the top of the page. Click one-minute typing test and begin typing when you are ready.”	
5.	After students complete their typing test, tell them to “Log-off the typing.com website.”	

Control Classroom – Typing Test		✓
1.	Instruct students to go to typing.com and enter their username and password	
2.	Say, “It’s time to take your typing test. Click the Test button at the top of the page. Click one-minute typing test and begin typing when you are ready.”	
3.	After students complete their typing test, tell them to “Log-off the typing.com website.”	

Appendix F

Sample Posttest Administration Script

1. Ask students to log onto their computer and open the internet browser.
2. As students are logging onto their computer, pass out research packets. Tell the students Leave this facedown until we tell you to do otherwise.
3. Once all students have logged onto their computer, opened the internet browser, and have a study packet say Hi, we are (introduce researchers) and we are from UT. We are here today because we need your help with a project. Everyone in the class is going to participate. We are here today to get started.
4. Today we will be doing some typing and handwriting. We have 5 things for you to do today: 1) a handwriting test, 2) a typing test, 3) a handwritten story, 4) a typed story, and lastly 5) some questions about you. We are going to go through everything together. But if you have any questions throughout just raise your hand. Are there any questions before we begin?
5. We are going to start with a handwriting test. We will get to the stuff on the computer in a bit. But for now, push your laptop aside. Turn over the paper on your desk. The paper should have a sticky note with your name on it and your lunch number should be on the first page. We will remove the sticky note before we leave, so your name will not be on any of the work you do today.
6. Go ahead and turn to the second page. You should be looking at a blank page with some lines on it. We are going to pass out a piece of paper with some sentences on it. Some of the sentences will make sense, others of them will not. When I say go, I want you to copy each sentence from our paper onto your paper. I want you to write as quickly as you can without making mistakes. Make sure you copy each sentence exactly as it is printed on the paper we are passing out. Are there any questions?
7. Instruct students to turn to handwriting speed test prompt. When everyone has the handwriting speed test prompt say, When I say go, you will have 2 minutes to write as many of these sentences as you can. Are there any questions?
8. You may begin!
9. Start timer. At 2-min say, Stop! Put your pencils down and turn back to the first page of your packet.
10. Now we are going to do a few things on the computer. You should have the internet browser open. Please go to the Newport Home Page and click on Useful Links on the side. Scroll all the way to the bottom. Under the technology heading you should see a link that says typing study. Please click that. It should take you to a new webpage. Make sure everyone is on the Online survey.
11. Once you've clicked the link you should be on a page that says, thank you for helping us with our study! Today, we will ask you to do some writing and typing. You will also answer a few questions about yourself. If you have any questions throughout, please raise your hand and someone will come help you. When you are ready to begin, press the arrow button. Everyone press arrow button.
12. Now, this page says please enter your ID number on the front of your packet. Once you have correctly entered your ID number press the arrow button.
13. Please re-enter your ID number. If you forget, it is listed on the front of your packet. Press the arrow button when you are done. Make sure you enter your ID number correctly, it is really important!

14. One the next page, click the box next to number one then press the arrow button.
15. Now we are going to typing speed test. We are going to pass out a piece of paper with some different sentences on it. Some of the sentences will makes sense, others of them will not. When I say go, I want you to type each sentence from our paper on this screen. I want you to type as quickly as you can without making mistakes. Make sure you type each sentence exactly as it is printed on the paper we are going to pass out. Are there any questions?
16. Instruct students to turn to the correct page of their study packet. Ensure that students do not start typing. When I say go, you will have 2 minutes to type as many of these sentences as you can. Are there any questions?
17. You may begin!
18. Begin timer. After 2 minutes say, Stop! Click the arrow button.
19. Ensure all students click the button. Great job! Now we are going to write a few stories. When everyone is ready tell the students, Click the arrow button.
20. For this, we are going to write a story. Push your laptop aside so you have room to write. I want you to hand write a story. I am going to read the first few words of the story to you then I want you to write a story about what happens next. You will have 1 minute to think about the story you will write, and then you'll have 5 minutes to write it. Do your best work. If you don't know how to spell a word, you should guess. You can use the words typed on the top of the page of as the first part of your sentence. If you have any questions, raise your hand and someone will come help you. Are there any questions now? In the middle of the story, I am going to ask you to circle the last word or punctuation mark you wrote. When I say that, I just want you to circle whatever you wrote and then keep writing. Are there any questions? Press the arrow button and turn to the last page of your study packet.
21. For the next minute, you should be thinking about 'my favorite thing about school is...'
22. Begin timing. If students start writing, instruct them to wait until you tell them to begin writing.
23. After 30 seconds say, you should be thinking about your 'favorite thing about school ...'..
24. After 1 minute, say, Start Writing. (Restart the stop watch.) Walk around the classroom to ensure the students are writing. As students are writing, walk around and advance their surveys to the screen that says, "You may start writing."
25. After 90 seconds, say, You should be writing about 'favorite thing about school ...'.
26. At 3 minutes, say please circle the last word or punctuation mark you wrote and keep writing.
27. At five minutes say, Stop and put your pencil down. Go ahead and turn your paper over. Put it face down. Make sure everyone finishes their story and turns over their paper. When everything is completed say Press the arrow button.
28. Now I want you to type a story. I am going to read the first few words of the story to you then I want you to type a story about what happens next. You will have 1 minute to think about the story you will write, and then you'll have 5 minutes to type it. Do your best work. If you don't know how to spell a word, you should guess. You can use the words typed at the top of the next screen as the first part of your sentence. If you have any questions, raise your hand and someone will come help you. Are there any questions? This time, in the middle, I am going to ask you type 3 "x's". When I say that, I want you to type the letter "x" three times, then keep typing. Are there any questions?
29. Okay, press the arrow button. For the next minute, you should be thinking about your 'favorite thing about summer is ...

30. Begin timing. If students start writing, instruct them to wait until you tell them to begin writing.
31. After 30 seconds say, you should be thinking about your ‘favorite thing about summer...
32. After 1 minute, say, Start Writing. (Restart the stop watch.) Walk around the classroom to ensure the students are writing.
33. After 90 seconds, say, you should be writing about your ‘favorite thing about summer...
34. At five minutes say, Stop typing and press the arrow button. Make sure everyone moves on to next page. Say Now we want you to answer a few questions about yourself! If you have any questions or need something explained, just raise your hand and someone will come help you.
35. Read social validity statements.

Appendix G

Sample Pretest Procedural Integrity Checklist

Observer Name: _____ Date: _____

	Pretest Data Collection Checklist	✓
1	Pass out research packets	
2	Introduce researchers	
3	Provide overview of study	
4	Provide handwriting speed test directions	
5	Instruct students to begin copying sentences	
6	At 2 minutes, instruct students to stop writing	
7	Instruct students to open Online Survey	
8	Instruct students to ID number	
9	Provide typing speed test directions	
10	Instruct students to begin typing sentences	
11	At 2 minutes, instruct students to stop typing	
12	Provide handwritten story instructions	
13	Read handwritten story starter	
14	At 30 seconds, remind students to continue think about their story starter	
15	At 1 minute, instruct students to begin writing	
16	At 90 seconds, remind students to continue writing about their story starter	
17	At 3 minutes, instruct students to circle last word/punctuation mark	
18	At 5 minutes, instruct students to stop writing	
19	Provide typed story instructions	
20	Read typed story starter	
21	At 30 seconds, remind students to continue think about their story starter	
22	At 1 minute, instruct students to begin typing	
23	At 90 seconds, remind students to continue typing about their story starter	
24	At 3 minutes, instruct students to type 3 “x’s”	
25	At 5 minutes, instruct students to stop typing	
26	Read demographic questions	

Appendix H

Sample Intervention Procedural Integrity Checklist

Intervention Classroom – Typing Lesson Days		✓
1.	Instruct students to go to typing.com and enter their username and password	
2.	Say, “Today is a typing lesson day. Click the Lessons button at the top of the page and continue your lessons.”	
3.	Allow students 10 minutes to engage in the typing lessons.	
4.	Monitor the room to ensure students are not playing games.	
5.	After 10 minutes, say “Stop, log-off the typing.com website.”	

Intervention Classroom – Typing Games/Test Day		✓
1.	Instruct students to go to typing.com and enter their username and password	
2.	Say, “Today is a typing game/test day. Click the Games button at the top of the page and play any of the games on the page.”	
3.	Allow students 9 minutes to engage in the typing games.	
4.	Say, “Now it’s time to take your typing test. Everyone quit your game and click the Test button at the top of the page. Click one-minute typing test and begin typing when you are ready.”	
5.	After students complete their typing test, tell them to “Log-off the typing.com website.”	

Control Classroom – Typing Test		✓
1.	Instruct students to go to typing.com and enter their username and password	
2.	Say, “It’s time to take your typing test. Click the Test button at the top of the page. Click one-minute typing test and begin typing when you are ready.”	
3.	After students complete their typing test, tell them to “Log-off the typing.com website.”	

Appendix I

Sample Posttest Procedural Integrity Checklist

Observer Name: _____ Date: _____

	Posttest Data Collection Checklist	✓
1	Pass out packets	
2	Introduce researchers	
3	Provide overview of study	
4	Instruct students to open Qualtrics	
5	Instruct students to enter lunch number	
6	Provide typing speed test directions	
7	Instruct students to begin typing sentences	
8	At 2 minutes, instruct students to stop typing	
9	Provide handwriting speed test directions	
10	Instruct students to begin copying sentences	
11	At 2 minutes, instruct students to stop writing	
12	Provide handwritten story instructions	
13	Read handwritten story starter	
14	At 30 seconds, remind students to continue think about their story starter	
15	At 1 minute, instruct students to begin writing	
16	At 90 seconds, remind students to continue writing about their story starter	
17	At 3 minutes, instruct students to circle last word/punctuation mark	
18	At 5 minutes, instruct students to stop writing	
19	Provide typed story instructions	
20	Read typed story starter	
21	At 30 seconds, remind students to continue think about their story starter	
22	At 1 minute, instruct students to begin typing	
23	At 90 seconds, remind students to continue typing about their story starter	
24	At 3 minutes, instruct students to type the number 1 three times	
25	At 5 minutes, instruct students to stop typing	
26	Read social validity statements	

Appendix J

Example Online Survey

Thank you for helping us with our study! Today, we will ask you to do some writing and typing. You will also answer a few questions about yourself. If you have any questions throughout, please raise your hand and a researcher will come help you.

When you are ready to begin, press the arrow button.



Please enter the username on the front of your packet.



Please re-enter the username on the front of your packet.



Thank you! Now we will begin the study.

Press the arrow button to begin.



Typing Speed Test



Great Job!



I want you to hand write a story. I am going to read the first few words of the story to you then I want you to write a story about what happens next. You will have **1 minute** to think about the story you will write, and then you'll have **5 minutes** to write it. Do your best work. If you don't know how to spell a word, you should guess. You can use the words typed at the top of the next page as the first part of your sentence. If you have any questions, raise your hand and researcher will come help you.



Now turn to the last page of your packet.

For the next minute, you should be thinking about "My favorite T.V. show is ..."

You may start writing!

Stop! Put your pencil down!

When I tell you, press the arrow button to continue.



Now I want you to type a story. I am going to read the first few words of the story to you then I want you to type a story about what happens next. You will have **1 minute** to think about the story you will write, and then you'll have **5 minutes** to type it. Do your best work. If you don't know how to spell a word, you should guess. You can use the words typed at the top of the next screen as the first part of your sentence. If you have any questions, raise your hand and researcher will come help you.



For the next minutes you should be thinking about "My favorite game is ..."

You may start typing!

My favorite game is ...

Stop!

When I tell you, press the arrow button to continue.



Where did you learn to type on a computer keyboard? (Select all that apply).

- ☐ School
- ☐ Home
- ☐ Typing Games
- ☐ Typing Class (either at school or other organization)
- ☐ I was never taught to type
- ☐ Other (please explain)



Have you had formal typing instruction on a computer keyboard (a specific class where you were taught to type)?

- ☐ Yes
- ☐ No



How old were you when you had formal typing instruction? (Select all that apply).

- | | |
|---------------------------------------|---|
| ☐ Kindergarten | ☐ 5th Grade |
| ☐ 1st Grade | ☐ 6th Grade |
| ☐ 2nd Grade | ☐ 7th Grade |
| ☐ 3rd Grade | ☐ 8th Grade |
| ☐ 4th Grade | ☐ Other (please explain) |



I am

- ☐ Male
 - ☐ Female
 - ☐ I prefer not to answer
-

I am

- | | |
|------------------------------------|--|
| ☐ 9 years old | ☐ 13 years old |
| ☐ 10 years old | ☐ 14 years old |
| ☐ 11 years old | ☐ 15 years old |
| ☐ 12 years old | ☐ I prefer not to answer |
-

I am in the

- ☐ 4th Grade
 - ☐ 5th Grade
 - ☐ 6th Grade
 - ☐ 7th Grade
-

I am

(Select all that apply).

- | | |
|--|---|
| ☐ Alaskan Native | ☐ Hawaiian or Pacific Islander |
| ☐ American Indian | ☐ Hispanic |
| ☐ Asian | ☐ White or Caucasian |
| ☐ Black or African American | ☐ I prefer not to answer |



Thank you for your help!

Appendix K

Student Social Validity

Please rate each statement about the typing lessons.

	1. Strongly Agree	2. Agree	3. Disagree	4. Strongly Disagree
I liked visiting typing.com each week.	☐	☐	☐	☐
I liked the typing lessons.	☐	☐	☐	☐
There were days when I did not want to complete the typing lessons.	☐	☐	☐	☐
There were days when I would have liked to do more typing lessons.	☐	☐	☐	☐

Please rate each statement about the typing games.

	1. Strongly Agree	2. Agree	3. Disagree	4. Strongly Disagree
I liked the typing games.	☐	☐	☐	☐
There were days when I would have liked to play more typing games.	☐	☐	☐	☐
There were days when I did not want to play the typing games.	☐	☐	☐	☐
I think the typing games have helped me type faster.	☐	☐	☐	☐

Please rate each statement about typing.com.

	1. Strongly Agree	2. Agree	3. Disagree	4. Strongly Disagree
I think the typing activities (lessons and games) make me better at typing a story on the computer.	☐	☐	☐	☐
I would like to continue visiting typing.com.	☐	☐	☐	☐
I do not want to continue visiting typing.com.	☐	☐	☐	☐
I think my friends should visit typing.com.	☐	☐	☐	☐

Appendix L
Teacher Social Validity

Please select the answer that best represents how you feel about each statement.

	1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
I liked having my students visit www.typing.com each week.	☐	☐	☐	☐	☐
I think the typing lessons were helpful.	☐	☐	☐	☐	☐
I think 10 minutes a day was a long enough time for my students to engage in the intervention.	☐	☐	☐	☐	☐
I think the typing lessons improved my students' typing skills.	☐	☐	☐	☐	☐
There were days when I wanted my students to type longer.	☐	☐	☐	☐	☐
	1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
I think the typing games improved my students' typing skills.	☐	☐	☐	☐	☐
I would like for my students to continue visiting typing.com .	☐	☐	☐	☐	☐
I will use typing.com as a typing intervention for future classes.	☐	☐	☐	☐	☐
I would recommend a fellow teacher have his/her class visit www.typing.com .	☐	☐	☐	☐	☐

Appendix M

Example Typing Lesson Screen

Welcome to Typing.com! We are going to start off really easy. On the next screen, just type **the letter J** with your **right index finger**.

To begin, press the **CONTINUE** button below.



[Return to Lessons](#)

CONTINUE

Appendix N

Presentation Order for Pretest/Posttest

	1	2	3	4	5
Pretest A	Handwritten Speed Prompt	Typed Speed Prompt	Story A - Handwritten	Story B – Typed	Demographic Questions
Pretest B	Handwritten Speed Prompt	Typed Speed Prompt	Story B - Typed	Story A - Handwritten	Demographic Questions
Pretest C	Handwritten Speed Prompt	Typed Speed Prompt	Story A - Typed	Story B - Handwritten	Demographic Questions
Pretest D	Handwritten Speed Prompt	Typed Speed Prompt	Story B - Handwritten	Story A - Typed	Demographic Questions
Pretest E	Typed Speed Prompt	Handwritten Speed Prompt	Story A - Handwritten	Story B – Typed	Demographic Questions
Pretest F	Typed Speed Prompt	Handwritten Speed Prompt	Story B - Typed	Story A - Handwritten	Demographic Questions
Pretest G	Typed Speed Prompt	Handwritten Speed Prompt	Story A - Typed	Story B - Handwritten	Demographic Questions
Pretest H	Typed Speed Prompt	Handwritten Speed Prompt	Story B - Handwritten	Story A - Typed	Demographic Questions

Appendix O

Standard CBM Instruction

1. Give each student the paper with the story starter written at the top – (provided).
2. **I want you to write a story. I am going to read the first few words of the story to you first and then I want you to write a story about what happens. You will have 1 minute to think about the story you will write, and then you'll have five minutes to write it. At three minutes, I'm going to ask you to circle the word you just wrote. You will circle to word and then continue writing. Do your best work. If you don't know how to spell a word, you should guess. Use the words written at the top of your paper as your first sentence. Are there any questions? For the next minute think about 'My favorite t.v. show is ...'.**
3. Begin timing
4. If students start writing, instruct them to wait until you tell them to begin writing.
5. After 30 seconds say, **"You should be thinking about 'your favorite t.v. show...'"**
6. After 1 minute, say, **"Start Writing."** (Restart the stop watch.) Walk around the classroom to ensure the students are writing.
7. After 90 seconds, say, **"You should be writing about 'your favorite t.v. show...'"**
8. At five minutes say, **"Stop and put your pencil down."**

Appendix P

Classroom Matching Data

Fourth-Grade Typing Speed Data				
Classroom	1	2	3	4
M (SD)	8.3 (3.29)	7.97 (3.58)	9.26 (3.65)	9.91 (3.96)
Range	13.5 [4-17.5]	11.7 [1.9-13.6]	11.8 [4.4-16.2]	12 [4.5-17.3]
Median for Class	7.6	8.5	9	10.45
Number of Students below Median for Class	11	9	6	8
Number of Students below Median for Grade (Median = 8.85)	13	11	5	6

- Intervention: Classrooms 1 and 4
- Control: Classrooms 2 and 3
- Classrooms 1 and 2 were matched. The mean and median typing speed for those classes were similar. Classroom 1 was selected as the intervention because there were more students in Classroom 1 whose typing speed scores were below the median for the grade.
- Classrooms 3 and 4 were matched; mean and median typing speed for those classes were similar. Classroom 4 was selected as the intervention classroom because there were more students in Classroom 4 whose typing speed scores were below the median for the grade.

Fifth-Grade Typing Speed Data

Classroom	1	2	3	4
M (SD)	14.6 (4.37)	9.77 (3.66)	11.38 (3.39)	10.75 (4.78)
Range	11.9 [9.8-21.7]	13 [5-18]	14.9 [3-18.4]	17.8 [2.3-20]
Median for Class	14.1	9.25	11.25	11.1
Number of Students below Median for Class	6	7	8	6
Number of Students below Median for Grade (Median = 8.85)	3	12	6	5

- Intervention: Classrooms 2 and 3
- Control: Classrooms 1 and 4
- Classrooms 1 and 3 were matched. The mean and median typing speed for those classes were similar. Classroom 3 was selected as the intervention because there were more students in Classroom 3 whose typing speed scores were below the median for the grade.
- Classrooms 2 and 4 were matched; mean and median typing speed for those classes were similar. Classroom 2 was selected as the intervention classroom because there were more students in Classroom 2 whose typing speed scores were below the median for the grade.

Appendix Q

Tables

Table 1

Interscorer Agreement

	Pretest			Posttest		
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range
Typing Test						
Speed	99.63	0.42	0.03	99.85	0.005	0.02
Accuracy	96.93	0.41	0.10	97.63	0.41	0.14
Handwriting Test						
Speed	100	0.0	0.00	100	0	0.00
Accuracy	98.26	0.41	0.10	97.32	0.04	0.13
Handwritten CBM						
TWW	99.02	0.43	0.05	98.74	0.20	0.09
CWS	95.10	0.41	0.15	96.07	0.03	0.12
Typing CBM						
TWT	99.66	0.41	.03	98.12	0.03	0.13
CTS	94.29	0.39	.15	94.41	0.05	0.15

Note.

TWW – Total Words Written

CWS – Correct Writing Sequences

TWT – Total Words Typed

CTS – Correct Typing Sequences

Table 2

Pretest Descriptive Statistics by Treatment Group

	Control			Intervention			
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	t-value
Typing Test							
Speed	10.40	4.572	19	10.07	3.97	15	0.37
Accuracy	85.91%	14.20	44.4	87.39%	12.95	52.9	-0.54
Handwriting Test							
Speed	11.21	3.58	16	11.96	5.76	41	-0.74
Accuracy	85.43%	17.08	63	87.00%	14.57	63	-0.49
Handwritten CBM							
TWW	54.14	20.18	87	53.21	17.63	78	0.24
CWS	46.95	17.95	75	49.71	18.52	76	-0.74
Typing CBM							
TWT	50.11	20.54	98	48.09	23.68	101	0.44
CTS	38.54	18.99	71	38.84	23.39	136	-0.07

Note.

TWW – Total Words Written

CWS – Correct Writing Sequences

TWT – Total Words Typed

CTS – Correct Typing Sequences

Table 3

Posttest Descriptive Statistics by Treatment Group

	Control			Intervention			
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	t-value
Typing Test							
Speed	13.17	4.34	19	12.97	5.29	25	0.20
Accuracy	88.00%	12.12	46.67	92.15%	10.48	46.67	-1.85
Handwriting Test							
Speed	13.90	4.41	20	14.16	3.91	19	-0.31
Accuracy	94.29%	9.25	40	92.56%	10.43	40	0.85
Handwritten CBM							
TWW	66.66	18.32	80	67.57	32.14	117	-0.21
CWS	58.80	18.67	71	61.98	23.28	121	-0.71
Typing CBM							
TWT	67.14	25.72	127	69.40	24.97	123	-0.44
CTS	61.53	26.30	121	64.69	24.73	130	-0.60

Note.

TWW – Total Words Written

CWS – Correct Writing Sequences

TWT – Total Words Typed

CTS – Correct Typing Sequences

Table 4

Intervention Descriptive Statistics by Treatment Group

	Control			Intervention			
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	t-value
Time 1							
Typing WPM	16.65	6.71	28	14.94	6.00	28	1.26
Typing Accuracy	94.57%	3.51	14	95.34%	3.03	12	0.33
Time 2							
Typing WPM	17.95	7.04	29	16.04	6.55	32	1.31
Typing Accuracy	95.78%	2.55	12	94.73%	3.75	23	1.48
Time 3							
Typing WPM	17.89	6.46	27	17.50	6.41	27	0.29
Typing Accuracy	95.61%	2.92	13	95.48%	2.61	12	0.21
Time 4							
Typing WPM	18.78	6.68	28	17.36	5.63	27	1.06
Typing Accuracy	95.73%	3.15	13	95.43%	2.70	12	0.48
Time 5							
Typing WPM	19.82	6.77	26	18.11	6.46	29	1.23
Typing Accuracy	97.01%	2.44	9	94.77%	3.18	12	3.82
Time 6							
Typing WPM	19.10	6.60	27	19.12	6.86	28	-0.01
Typing Accuracy	95.64%	2.56	12	95.92%	2.98	14	-0.47
Time 7							
Typing WPM	19.60	6.69	31	19.87	7.58	33	-0.18
Typing Accuracy	96.40%	2.60	10	95.06%	4.06	24	1.83
Time 8							
Typing WPM	19.40	6.69	29	19.13	6.99	33	0.19
Typing Accuracy	96.13%	3.24	13	94.30%	5.20	31	1.96
Time 9							
Typing WPM	18.95	6.98	30	20.22	7.00	32	-0.85
Typing Accuracy	96.21%	2.41	10	96.39%	2.53	14	-0.34
Time 10							
Typing WPM	19.40	6.52	27	20.68	7.07	31	-0.90
Typing Accuracy	95.98%	2.78	11	96.26%	3.12	20	-0.46

Table 5

Pretest Within-Subject Data Disaggregated by Response Format

	Handwritten			Typed			t-value
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	
Speed Test							
Speed	11.64	4.94	42	10.21	4.22	19	-2.62**
Accuracy	86.33%	15.63	63	86.76%	13.45	52.9%	0.21
CBM Response							
Total Words	53.61	18.67	87	48.96	22.30	102	2.12*
Correct Sequences	48.53	18.23	76	38.71	21.52	136	4.96***

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 6

Writing Outcome Variables Disaggregated by Grade and Response Format

		Handwritten CBM		Typing CBM		t-value
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Pretest	4 th Grade	52.88	18.68	48.30	25.29	-1.35
Production	5 th Grade	55.56	19.49	49.85	19.09	-2.01*
Pretest	4 th Grade	48.09	19.35	36.66	23.94	-3.57**
Quality	5 th Grade	50.38	18.26	41.12	19.17	-3.67**
Posttest	4 th Grade	65.85	17.74	64.44	23.64	-0.48
Production	5 th Grade	68.69	23.82	70.33	24.43	0.56
Posttest	4 th Grade	58.09	17.37	59.39	23.75	0.46
Quality	5 th Grade	63.37	24.45	65.16	24.67	0.60

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 7

Posttest Within-Subject Data Disaggregated by Response Format

	Handwritten			Typed			t-value
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	
Speed Test							
Speed	14.04	4.12	20	13.06	4.88	25	-1.87
Accuracy	93.32%	9.92	40	90.33%	11.36	47	-2.20*
CBM Response							
Total Words	67.18	21.09	117	68.41	25.19	127	0.23
Correct Sequences	60.61	21.42	121	63.31	35.34	130	0.98

* $p < .05$

Table 8

Student Social Validity

Items	<i>M (SD)</i>
I liked visiting typing.com each week.*	2.62 (.86)
I liked the typing lessons.*	2.83 (.91)
There were days when I did not want to complete the typing lessons.	2.04 (1.09)
There were days when I would have liked to do more typing lessons.*	2.45 (1.19)
I liked the typing games.*	3.15 (1.00)
There were days when I would have liked to play more typing games.*	3.00 (.98)
There were days when I did not want to play the typing games.	2.58 (1.20)
I think the typing games have helped me type faster.*	2.64 (1.08)
I think the typing activities (lessons and games) make me better at typing a story on the computer. *	3.19 (.92)
I would like to continue visiting typing.com.*	2.45 (1.18)
I do not want to continue visiting typing.com.	2.26 (1.13)
I think my friends should visit typing.com.*	2.92 (1.11)

*Denoted items that were reversed scored.

Table 9

Teacher Social Validity

Items	<i>M (SD)</i>
I liked having my students visit www.typing.com each week.	4.25 (0.5)
I think the typing lessons were engaging.	3.75 (1.26)
I think the typing lessons improved my students' typing skills.	4.25 (0.5)
I think 10 minutes a day, 3 days a weeks, was sufficient time for my students typing skills to improve.	3.5 (0.58)
There were days when I wanted my students to type longer.	2.75 (0.96)
I think the typing games were engaging.	4.5 (0.58)
I think the typing games improved my students' typing skills.	4.25 (0.5)
I would like for my students to continue visiting typing.com .	3.5 (0.58)
I will use typing.com as a typing intervention for future classes.	3.5 (1)
I would recommend a fellow teacher have his/her class visit www.typing.com .	4 (0)

Table 10

Correlation Matrix for Posttest Typing Outcome Variables

	Lessons Completed	WPM	ACC	TWT	CTS
WPM	0.62**	--			
ACC	0.24	0.23*	--		
TWT	0.55**	0.69**	0.13	--	
CTS	0.55**	0.71**	0.25*	0.94**	--

* $p < .05$ ** $p < .01$ *Note.*

WPM – Words per Minute

ACC - Accuracy

TWT – Total Words Typed

CTS – Correct Typing Sequences

Table 11

Correlation Matrix for Difference between Pretest and Posttest Typing Outcome Variables

	Lessons Completed	WPM	ACC	TWT	CTS
WPM Difference	0.30*	--			
ACC Difference	-0.04		--		
TWT Difference	0.05	0.03	-0.09	--	
CTS Difference	0.08	0.01	-0.05	0.89**	--

* $p < .05$ ** $p < .01$

Appendix R

Figures

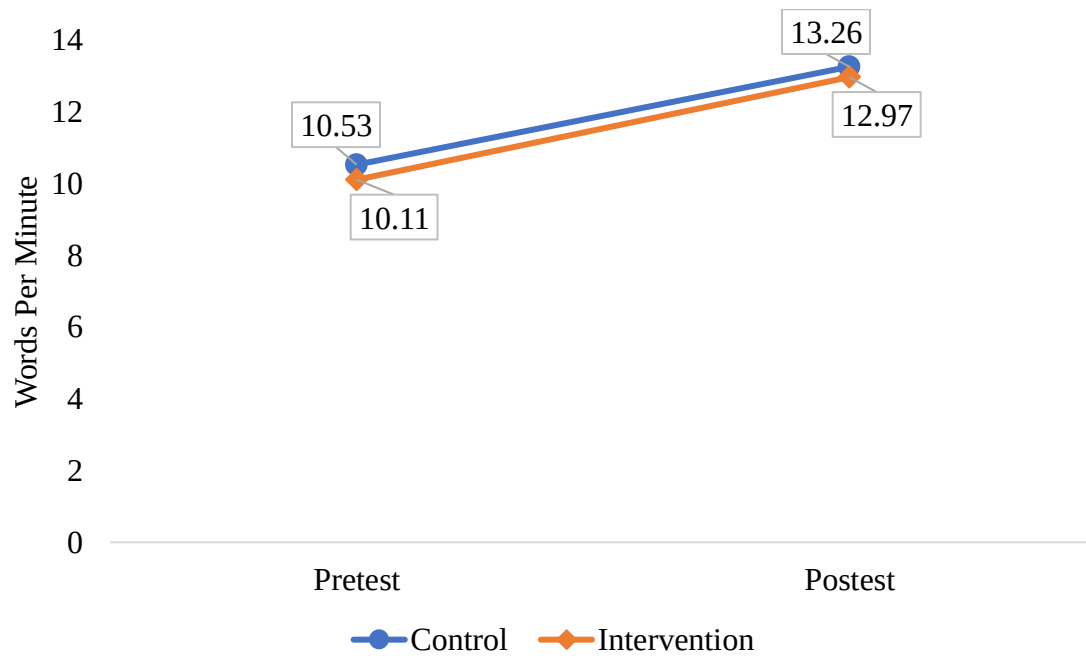


Figure 1. Student Typing Speed

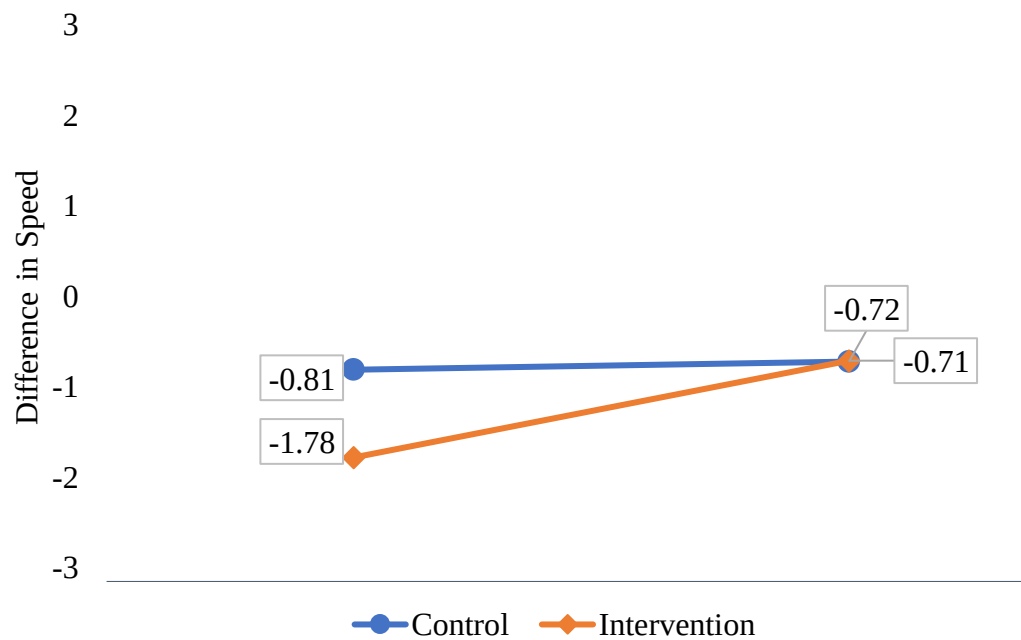


Figure 2. Production Differences between Typed and Handwritten Responses

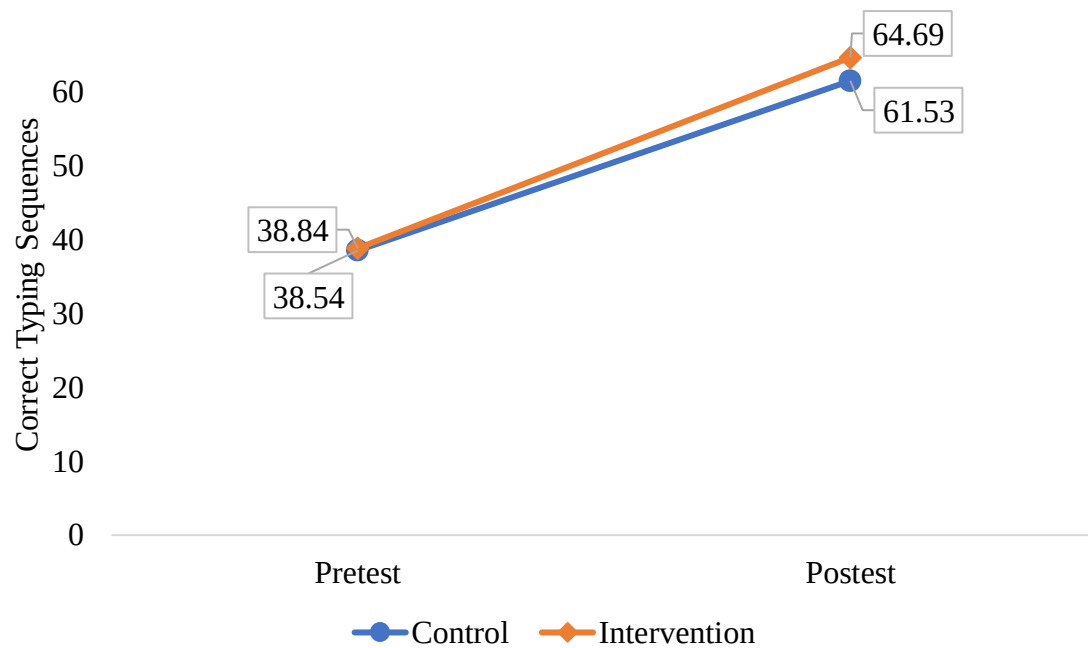


Figure 3. Student Story Quality

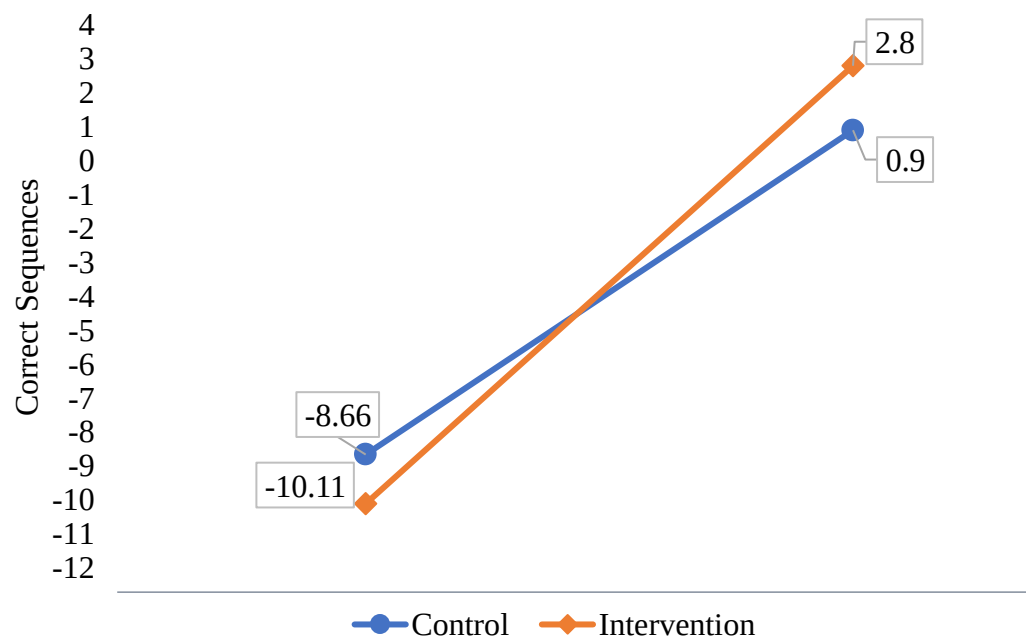


Figure 4. Quality Differences between Typed and Handwritten Responses

Vita

Stephanie Daniels was born in Hiddenite, North Carolina. She graduated in 2015 from the University of North Carolina at Chapel Hill with a B.A. in Psychology and a minor in Speech and Hearing Science. In 2018, she received her M.S. in Educational Psychology from the University of Tennessee at Knoxville and is currently pursuing her Ph.D. in school psychology at the University of Tennessee at Knoxville. Stephanie will begin her internship in the fall of 2019 with the Tennessee Internship Consortium in Psychology and will graduate in August of 2020.