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The Impact of Technology on Handwriting Instruction in Kindergarten Students

Tricia Van Regenmorter
Northwestern College - Orange City

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Tricia Van Regenmorter

Northwestern College

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Dr. Sara Waring-Tiedeman

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Abstract

The purpose of this action research project was to study the outcome of computer-assisted instruction on handwriting quality. Quality handwriting includes legibility, orientation, formation, size, and placement on a base line. The participants were fourteen Kindergarten students in a preschool through eighth grade private school in a suburban setting. The fourteen participants were placed into two instructional groups through random grouping. One group of participants received computer-assisted instruction while the other group received teacher-assisted direct instruction. Participants participated in their assigned instructional approach for 10 minutes 3-4 times a week for four weeks. Data was collected quantitatively. At the conclusion of the four-week intervention, the results indicated no one specific instructional approach yielded a statistically significant greater improvement when comparing the two approaches.

The Impact of Technology on Handwriting Instruction in Kindergarten Students

Handwriting, the act of forming letters in print, is an essential skill students must master in the early elementary years. As students master this critical skill, they are able to express themselves through the composition of written text. In 2009, the Common Core State Standards were launched to address academic expectations for all students K-12 across the United States (Common Core State Standards Initiative, 2019). As part of the adoption, standards for writing were addressed for students beginning in Kindergarten. Kindergarten students are expected to master multiple writing skills. They must be able to print many upper- and lowercase letters, write a letter or letters for most consonant and short-vowel sounds, spell simple words phonetically, and use a combination of drawing, dictating, and writing to compose opinion, informative/explanatory, and narrative texts (Common Core State Standards, 2009). In order to meet these benchmarks, students must have quality, legible handwriting that is becoming fluent. Quality handwriting must include correct formation, orientation of most letters and numbers correctly, grade-appropriate size, and placement on a base line (Handwriting without Tears, 2014). Quality handwriting is not only important to produce complex written composition (Cahill, 2009), but it has shown to predict later academic achievement in other areas as well (Dinehart, 2015 & Cameron, Brock, Murrah, Bell, Worzalla, Grissmer, & Morrison, 2012).

Much research has been conducted on topics and skills that directly influence handwriting, including fine motor and literacy development. There is even research available on the impact of technology-assisted instruction and direct instruction on academic skills. Handwriting is a complex and critical skill for young children to master, but not much, if any, research has been done to identify if technology-assisted instruction or direct instruction has

larger contributions to quality handwriting. The comparison of these two instructional approaches could have the potential to impact the instruction of handwriting in early childhood.

The purpose of the research is to examine and determine an effective instructional approach to improve the quality of handwriting by considering current research on the multiple facets that contribute to handwriting including literacy and fine motor development. The research will also consider the importance of handwriting fluency and then consider two instructional approaches. The current research will be examined to provide a basis for the research question, which states: Does computer-assisted instruction impact Kindergarten students' handwriting compared to teacher-directed instruction utilizing paper and pencil practice?

Review of the Literature

Literacy Development

Handwriting is very closely linked to a child's development of emergent literacy skills; skills that build the foundation for writing and reading later in life. Emergent literacy skills include, but are not limited to phonological awareness, alphabetic principle, print concepts, and written language (Cameron, Cottone, Murrah, & Grissmer, 2016). Handwriting and reading are two interconnected components that work together. Before children pick up a pencil and write, they are exposed to language and books from a very young age. From the time a child is born, emergent literacy skills are being developed. The National Association for the Education of Young Children (NAEYC) and the International Reading Association (IRA) (2009) reveal that a child's early exposure to nursery rhymes, books, and adults talking to them are vital in the development of learning to read and write. These early experiences set the foundation for literacy development throughout childhood.

As children enter preschool, they become more exposed to literacy skills, such as phonological awareness, print concepts, and letter-sound recognition. Children's understanding of letter names, sounds, and symbols are commonly referred to as alphabet knowledge. Alphabet knowledge is an essential component to learning to read and write (Jones, Clark, & Reutzel, 2012). The recognition of letters, a component of alphabet knowledge, is the start of being able to physically draw lines and curves that form legible letters of the alphabet. Fluent recognition of letters allows children to visualize in their mind what each letter looks like in order to form each letter correctly on paper. Many educators that are tasked with teaching alphabet knowledge and ensuring mastery, include the production of the letters of the alphabet. This is considered best practice. Current research states that effective alphabet knowledge instruction includes the element of letter form production, both uppercase and lowercase letters (Jones et al., 2012). The writing of letters has shown to assist young children in their letter recognition ability. Dinehart (2015) cited a study of preschoolers in which participants either practiced writing words with a writing utensil or typing the words on a keyboard. The results indicated that students in the writing group compared to the typing group had greater scores on a letter recognition test (Dinehart, 2015). The foundation of handwriting includes so much more than knowledge of the alphabet. Results from a study conducted by Maldarelli, Kahrs, Hunt, and Lockman (2015) suggests that the beginning stages of handwriting which occurs in Preschool and Kindergarten are also reliant on motor and cognitive processes.

Fine Motor Development

Emergent literacy skills, together with emergent writing, are closely associated with fine motor skills (Cameron et al., 2016). Motor development can be categorized in to two types: fine (small motor movements) and gross (large motor movements). For the purpose of the research question, literature surrounding fine motor development, as well as the visual component will be

synthesized. Fine motor development is the coordination of small muscles in the hands and fingers. Tasks that require fine motor include cutting, tying shoe laces, buttoning, zipping, and most significantly, writing among a variety of other tasks. These skills not only help to foster independence during early childhood, but are also indicators of academic achievement later in school.

Before children enter Kindergarten, they are typically assessed to determine their readiness for school. A key component of this assessment is fine motor skills (Cameron et al., 2012). Fine motor skills are assessed prior to Kindergarten entry because students complete many tasks throughout the school day that require dexterity and hand strength. Students spend almost half of the school day devoted to these fine motor related activities (Cameron et al., 2012). Even after Kindergarten, students are engaged in fine motor activities 30-60% of their school day and 85% of that time involves paper and pencil work (Dinehart, 2015). Cameron et al. (2012) cited a study that determined preschool students with strong motor skills reached a higher level of reading success in third grade. Children with strong fine motor skills also experience greater achievement during Kindergarten. Researchers concluded that children with strong fine motor skills showed greater gains from the beginning to the end of Kindergarten in a variety of literacy skills compared to students with weak fine motor skills (Cameron et al., 2012). The dominant motor control task involved in handwriting is the way in which a student grasps a pencil. A young child's pencil grip matures and develops as their fine motor skills strengthen. Lifshitz and Har-Zvi (2015) states a mature pencil grip is stable, yet dynamic. Stable enough to grasp the writing utensil for a prolonged period while dynamic enough that the fingers allow the pencil to move freely during the formation of letters. When a grip is not stable or dynamic, it can lead to writing that is slow and requires much effort (Lifshitz & Har-Zvi, 2015).

Many factors contribute to a students' success with fine motor. It is not nearly enough to relegate strong fine motor skills to simply the coordination of small muscles in hands and fingers. It also requires visual and motor skills to work in conjunction with one another. This is known as visual-motor integration. High ability levels of visual-motor integration have shown to produce more legible handwriting and a quicker handwriting pace in Kindergarten students (Maldarelli, Kahrs, Hunt, & Lockman, 2015). Not much research has been done on exactly how the visual and motor systems work together, but there are significant correlations between visual motor integration and handwriting (Pfeiffer et al., 2015). A recent study was conducted by researchers that set out to discover exactly how these two systems work together to impact handwriting in children and adults using a visual tracking device. Participants wore the tracking device during tasks of single letter copying, and real and nonsense three-letter word copying. Copying tasks have proven to be more effective in handwriting development compared to tracing (Maldarelli et al., 2015). During tasks that require copying, students must process visual information, visualize a mental representation, and then organize motor movements to replicate the image (Cameron et al., 2012). Researchers discovered that during handwriting tasks, children re-fixated their gaze often and for prolonged periods of time, but the frequency and time span decreased with age (Maldarelli et al., 2015). As children grow and develop, so do their visual abilities which promotes handwriting fluency. When students can visually fixate on a stimulus, or what is to be copied, quickly, the speed of their handwriting also increases. Handwriting is a seemingly simple task, but is dependent on the coordination of visual-motor integration (Maldarelli et al., 2015).

Executive function. The act of handwriting is dependent on multiple factors, including literacy development and fine motor development. The association between fine motor and

executive functioning as it relates to handwriting and academic achievement has been studied in the literature. Executive function encompasses skills such as attentional shifting, working memory, and inhibitory control (Cameron et. al., 2012). Executive functioning skills are stored in the prefrontal cortex of the brain which is also stimulated by fine motor activities (Dinehart, 2015). A study was conducted over the span of three years in which researchers examined the role of executive function and fine motor skills in relation to academic achievement of Kindergarten students (Cameron et al., 2012). Researchers discovered that executive function had a positive correlation with the overall score for fine motor. However, the study also resulted in executive function and fine motor having separate contributions on Kindergarten academic achievement in the fall and contributed to the academic improvement from beginning to the end of the school year (Cameron et al., 2012). One of the fine motor tasks was design copy in which participants had to copy shapes using a pencil. This task was analyzed with the consideration of executive function and was shown to predict large gains in phonological awareness (Cameron et al., 2012). One of the components of executive function is one's ability to attend to relevant stimuli and Kindergarten students who have already learned to copy forms and letters, can shift their attention to learning more complex skills. In contrast, Kindergarten students with weak fine motor skills, must deploy their attention to grasping a pencil and attending to the specific movements needed to form letters rather than learning foundational skills for reading. A students' cognitive ability, fine motor skill, and executive functioning all contribute to their handwriting and academic progress.

Handwriting Fluency

When children begin to truly write letters and words, it is a slow, methodical process of recalling the mental representation of a letter, and then putting pencil to paper and coordinating visual and motor movements to reproduce the letter. This process eventually becomes automatic

or fluent. Fluency in handwriting is defined as the rate in which children can access and retrieve from memory letter forms, and then write letters of the alphabet correctly (Kim, Otaiba, Puranik, Folsom, & Gruelich, 2014; Puranik, Patchan, Sears, & McMaster, 2017). Handwriting fluency is a key component in handwriting as students not only need to learn how to form letters, but must be able to do it quickly. When a student can write quickly and fluently, they do not need to spend much thought on the process of forming a letter; it becomes a natural, fluid process during which students can focus their attention to the content of their writing. A student's handwriting fluency is difficult to measure until they have mastered letter names and sounds. While addressed previously, a large component of handwriting is the visual-motor aspect. However, with handwriting fluency, students must also access and retrieve letters from memory which requires prior knowledge of the letters of the alphabet (Kim et al., 2014). This can make it difficult to assess handwriting fluency in Kindergarten students as they are in the process of mastering letter names and sounds. Recognition of letters must come before students are tasked with recalling from memory the visual image of letters. Studies have shown that when handwriting fluency is assessed, on average students are able to write 10 letters accurately within 60 seconds at the end of Kindergarten (Kim et al., 2014; Puranik et al., 2017). Puranik et al. (2017) revealed that when Kindergarten students are given an untimed alphabet writing (AW) fluency task, the scores were better predictors of quality sentence writing compared to the timed AW task. Even so, it is difficult to measure a Kindergarten students' handwriting fluency, but the automatic access, retrieval and production of letters is an important component to later writing success.

Handwriting requires extensive cognitive processes in order to be able to access and retrieve letters from a student's working memory before producing the letters correctly. When students' handwriting is not fluent and automatic it can cause a strain on their ability to compose

a text (Puranik et al., 2017). Research has shown that when first-grade students receive instruction in handwriting fluency, there is an increase in their compositional fluency (Puranik et al., 2017). When students do not have to spend much effort on the formation of letters, they are able to spend more mental effort on the writing and composing of a text. Additionally, a study was conducted in Australia, that revealed higher handwriting automaticity in Kindergarten students who received instruction on revising strategies compared to students who did not. Results also showed no correlation between handwriting automaticity and handwriting instruction (Malpique, Pino-Pasternak, & Valcan, 2017). However, Puranik et al. (2017) cited an intervention that showed improvement in first-grade student's handwriting fluency. The intervention consisted of practice naming and writing letters. While both studies portray conflicting evidence regarding handwriting fluency, this may be due in part to the age of the participants. Not only would low letter naming fluency negatively affect handwriting fluency, memory and fine motor control would also have an effect. First grade students would be more developed in these areas compared to Kindergarten students. Handwriting fluency, a transcription skill, is a foundational component to writing composition. Kindergarten students can efficiently produce words, sentences, and ideas in their writing when there is some level of fluency in handwriting (Kent, Wanzek, Petscher, Al Otaiba, & Kim, 2013). When students are fluent, they can expend more mental effort on the content of their writing. As students receive handwriting instruction, the ease and automaticity of the retrieval and production of letters should also be considered (Puranik et al., 2017) as it is a necessary component when students begin composing written work.

Teacher-Directed Explicit Instruction

Explicit instruction is defined as a direct approach that is structured and systematic. This teaching methodology is a scaffolded process that includes clear demonstrations of the

instructional target and student practice with feedback (Archer & Hughes, 2011). When explicit instruction is combined with handwriting instruction, teachers demonstrate the formation of each letter followed by student practice. The teacher is guiding the student through the process of forming the letter correctly and providing feedback as necessary. As a student watches the demonstration, they are then able to replicate or copy the teacher's work. The task of copying has shown to be an effective process in the development of handwriting (Maldarelli et al., 2015). A systematic approach to handwriting is beneficial for the development of handwriting skills (Cahill, 2009).

The development of handwriting is a complex skill as it requires multiple facets, cognitive, language, visual, and motor, to work in coordination with one another. Due to the complexity, students may struggle with handwriting because of a variety of underlying skills. Students may not have the motor dexterity to grasp and maneuver a writing utensil while others may have decreased visual-motor skills. Researchers and occupational therapists conducted a study to determine the effectiveness of two approaches of commonly-used handwriting interventions for students in first and second grade (Howe, Roston, Sheu, & Hinojosa, 2013). The two approaches utilized were a visual-perceptual-motor approach and a motor learning approach where the practice of letter formation and composition are significant factors in handwriting improvement. Participants in the intensive practice group, motor learning approach, had greater results in handwriting legibility compared to the students in the visual-perceptual-motor group. The students in the motor learning group were engaged in low-level (copying) and high-level (text generation) handwriting activities. Researchers concluded that handwriting instruction that includes intensive practice and instruction yields greater improvements in a student's handwriting ability (Howe et al., 2013). A multisensory approach to handwriting has

also proven to be effective in improving the handwriting quality in first grade students (Roberts, Derkach-Ferguson, Siever, & Rose, 2014). Researchers compared the effectiveness of a teacher-designed instructional program to a multisensory program, Handwriting without Tears. Handwriting without Tears (HWT) was developed by an occupational therapist that is founded on developmentally appropriate practices which includes introducing letters in a scaffolded sequence while incorporating multisensory experiences (Handwriting without Tears, 2018). Participants in the study who received the HWT program scored significantly higher on the Minnesota Handwriting Assessment compared to students who did not receive instruction from the HWT program (Roberts et al., 2014). Cahill (2009) also suggests an approach known as blocked practice. Blocked practice allows for students to practice writing different letters or sights words to improve letter formation (Cahill, 2009). The consistent, blocked practice can aide a student's motor memory of letter formation. As noted earlier, when a student can produce letters without much mental effort, their handwriting fluency increases. Based on the literature, handwriting instruction that is structured, direct, multisensory, and includes repetition has shown to improve the quality of handwriting.

Educators in early childhood disagree whether a Kindergarten student's handwriting difficulty necessitates an intervention or whether the problem will resolve on its own over time. Those in opposition of intervening reason that when students are pressured to write letters correctly, they are less focused on free writing. The added pressure may also cause students to view writing as a difficult task. While other researchers are in favor of intervening in kindergarten because of the significance handwriting has on later achievement (Lifshitz & Harzvi, 2015). Lifshitz and Har-Zvi (2015) released a study in 2015 that examined the effects of an intervention on handwriting quality in Kindergarten students. Participants either received the

handwriting intervention or received instruction in phonological awareness. The students who received the handwriting intervention demonstrated a greater improvement in letter formation, quality and intensity, spatial positioning, directionality, and writing letters on the line (Lifshitz & Har-Zvi, 2015). Addressing handwriting difficulties in Kindergarten can allow for students to feel a sense of pride and accomplishment when another person is able to read their writing. As students begin using written language to communicate, the quality and legibility of handwriting becomes of greater importance. There are many components to handwriting that determine its quality. The Minnesota Handwriting Assessment (MHA) has stated five key components to quality handwriting: legibility, form, alignment, size, and spacing (Roberts et al., 2014). The Standards for the Production and Presentation of Writing, as developed by Handwriting without Tears (2014), also echo those same five components. The standards also include the physical development for handwriting such as pencil grip and the use of the non-writing hand to stabilize paper during writing (Handwriting without Tears, 2014). These five components contribute to a students' handwriting quality and when they are well-developed, allows for the student to concentrate on composing written text. Due to the importance of quality handwriting, direct, explicit instruction should begin in Kindergarten (Lifshitz & Har-Zvi, 2015).

Technology-Assisted Instruction

In recent years, technology has become an integral part in the everyday lives of children. Neumann and Neumann (2014) cited a survey that revealed over half of 0-8-year old children have access to touch-screen devices at home. Many young children have access to technology at school, as well. In a study of 56 teachers in the Midwest, computers were available in 98% of the early childhood classrooms surveyed (Ntuli & Kyei-Blankson, 2012). There has been a push for the integration of technology for learning and instruction. Van Deursen, Allouch, and Ruijter (2016) state that this push for technology integration is a means to prepare children for the 21st

century. The NAEYC and the IRA (2009) also recommend educational software and other technology tools are a necessary component of high-quality early literacy experiences. The use of technology for learning and instruction has become widespread as studies have shown the positive effects that integrating technology can produce.

The integration of computers in education has been commonly referred to as computer-assisted instruction. For the purpose of this literature review the integration of any technology device (i.e. computers, tablets, interactive whiteboards, etc.) will be referred to as technology-assisted instruction (TAI). As the term suggests, technology-assisted instruction is the use of technology to aid in the instruction for students. The use of TAI has shown positive correlations to the improvement of student learning. Chai (2017) conducted a study of three pre-K students with developmental delays to determine the effectiveness of an iPad app on the participants phonological awareness (PA) skills. Participants utilized a research-developed app in a small-group setting that targeted initial phonemes individualized for each child. As a result of the study, all three participants demonstrated an improvement of PA skills, including some of the target phonemes of their peers (Chai, 2017). The participants' PA skills had a positive correlation when remediated with TAI via a tablet. Computers have also shown to result in academic growth for ELLs. A study was conducted of ELLs in two charter schools which revealed that the use of TAI resulted in students coming close to reaching the achievement gap compared to the students who did not receive TAI (Keengwe & Hussein, 2013). While the researchers concluded positive results with technology-assisted instruction for ELLs, they also caution the use of technology. Interactive whiteboards (IWB) have also shown to have positive correlations on improving the learning outcomes of students. A study examined the effect of letter-sound instruction using a SMART board in a small group setting for three kindergarten students on Individualized

Education Plans (IEP). The study resulted in the improvement of target letter-sounds for all three participants (Campbell & Mechling, 2009). All three mentioned studies resulted in positive effects for students with learning disabilities in the use of technology-assisted instruction. The use of technology has also shown positive affects in other areas when integrated into the curriculum.

Many children are exposed to technology starting at an early age and it is a part of their everyday lives (Neumann & Neumann, 2014). When combined with an educational component, it becomes a motivating and engaging feature in a student's school day. A research study was released in 2015 that studied the views of teachers on the use of iPad tablets with children aged 3-13 years old (Flewitt, Messer, & Kucirkova, 2015). At the conclusion of the study, many teachers commented on students' engagement when using the tablets during literacy activities noticing that students seemed to be motivated by the independency that the tablet allowed as well as being provided with immediate feedback (Flewitt et al., 2015). One of the teachers in the study remarked that the students were drawn to the iPads like "bees to a honeypot" (Flewitt et al., 2015). Neumann and Neumann (2014) suggest that the use of tablets allows for a multi-sensory interactive experience which could be a factor that increases students' motivation. Technology-assisted instruction has not only shown to be a motivating factor, it has resulted in academic success as noted above.

This research study will be exploring whether technology-assisted instruction using a handwriting iPad app impacts Kindergarten students' handwriting when compared to teacher-directed handwriting instruction. Literature is available on components that influence handwriting, such as fine motor and literacy development and on the effects of TAI for academic learning, as well as the connection between handwriting and later academic achievement.

However, the researcher was unable to find recent research on the connection between handwriting and technology. By combining TAI with handwriting instruction, the researcher hypothesizes that aspects of students' handwriting will improve, such as memory and orientation, while pencil grip, a skill necessary for handwriting, will not be affected.

Methods

Participants

The action research was conducted in a kindergarten classroom during the 2018-2019 school year. The kindergarten classroom is the only section of Kindergarten in a suburban private school. The participants of the action research consisted of 14 students with diverse ethnic backgrounds. All of the students' native language is English. None of the students are on Individual Educational Plans (IEPs) or receive outside services beyond additional classroom support from classroom teacher and classroom aide. Three of the 14 students utilize a specialized pencil grip that is added on to their pencil during handwriting and writing activities to aide in establishing a correct and efficient grip. All 14 kindergarten students participated in the study, seven boys and seven girls. Participants ranged in age from five to six years old.

Preparation of Student

In the classroom, students have received weekly handwriting instruction based off the designated English Language Arts (ELA) curriculum adopted by the school. The handwriting instruction averages three days per week as outlined by the ELA curriculum. The curriculum covers one letter per week for the first half of the school year and progresses to one or two letters per week, depending on the phonics concept of the week. Prior to beginning the ELA curriculum at the start of the school year, all students received a brief letter recognition and sound review, which included reviewing correct letter formation. Technology was integrated into the classroom

instruction in the beginning of the school year in the form of SMART board technology. Students were not exposed to tablet technology during classroom instruction except for when students took the Measures of Academic Progress (MAP) test in the fall and winter. The intervention was when students in the study group were first exposed to the use of tablets during instruction.

Data Collection

The purpose of this study was to find out if handwriting apps on iPads is an effective strategy to improve students' overall handwriting ability. The study took place over a span of seven weeks. The first week of the study, students' handwriting were assessed individually by the researcher using the Screener of Handwriting Proficiency, developed by Learning without Tears. The assessment targeted four critical skills through name writing, lower- and upper-case letter writing, number writing, and sentence writing. The four targeted skills include: memory, orientation, placement, and sentence skills. In addition, name writing and other handwriting concerns (formation, size, neatness, speed, posture, pencil grip, and helper hand) were also included in the screener (Handwriting without Tears, 2018). After completion of the pre-assessment, students were grouped at random into two groups, a control group and a study group. The students in the control group received teacher-directed explicit handwriting instruction while the study group received technology-assisted instruction in the form of a handwriting app on classroom iPads. Students in the study group utilized the free version of the app Touch and Write developed by classroom teachers under the company FizzBrain (Cort & Cort, 2019). Both groups of students received their specified handwriting instructional approach for 10 minutes/day over the span of four weeks. Students participated in a total of 14 sessions (3-4 sessions/week). After

the four-week intervention, students were assessed again using the same measurement tool, the Screener of Handwriting Proficiency, during the sixth and seventh week of the study.

The Screener of Handwriting Proficiency assesses the following components: memory, orientation, placement, sentence skill, name writing, and other handwriting concerns (Handwriting without Tears, 2018). Memory, orientation, placement and sentence skill are scored by counting the total number of errors for each. Errors in memory include failing to write the letter or number, writing the wrong letter or number, and writing an unrecognizable letter or number. Backward letters, also known as reversals, are considered an orientation error. Placement errors include the inability to place letters or numbers correctly on a base line with a margin of error of 1/8". The sentence writing portion is assessed for five key components: a beginning capital letter, space between words, lowercase words, letters in words close together, and ending punctuation (Learning without Tears, 2018). The scoring of the assessment is done using the online scoring component and produces an overall percentage of the student's handwriting ability as well as a score for each area assessed. The students' handwriting score does not include name writing and the other handwriting concerns, but the website does allow the teacher to include any errors with name writing and observational notes for the other handwriting concerns of formation, neatness, speed, size, posture, pencil grip, and helper hand.

Students in the control group, teacher-directed instruction, received handwriting instruction via the Kindergarten classroom aide while students in the study group were overseen by the classroom teacher. The control group was guided through step-by-step demonstrations of each letter, upper- and lower-case, and number while immediately practicing the letter or number using a variety of tools, including pencil and paper, whiteboards, and salt boxes. The whiteboards and saltboxes mimic pencil and paper practice, but provide a novelty experience for

students. During students' practice of number and letter writing, students were provided with explicit feedback and correction to improve their handwriting. Three out of the fourteen sessions involved tracing practice while the other 11 sessions were copying practice on multiple mediums (paper, whiteboard, and salt boxes). Students in the study group utilizing the iPad app, Touch and Write, were self-paced through the alphabet and numbers 0-9. As students worked their way through the alphabet, they were given the upper- and lower-case of each letter before moving on to the next letter of the alphabet. The same was true for numbers as students started at zero and worked their way numerically to the number 9 and then started over from the beginning. The app used a visual image of a character to show students were to start forming the letter or number. The app also provided gentle, frequent feedback as students traced each letter and number. If a student traced outside of the model, the app would erase and have students repeat the stroke. After the completion of each upper- and lower-case letter and number, students would see a screen of balloons celebrating their accomplishment of forming the designated letter or number correctly.

Ethics

This action research project did not require IRB approval because it met all three of Northwestern's IRB exemption criteria. The research posed minimal risk to students. Handwriting is a normal task that is conducted in Kindergarten classrooms and the use of technology is a common practice in educational settings with students. Second, the action research project was conducted in the students' general education classroom during typical school hours. Finally, the action research involved normal educational practices and assessments. The researcher compared technology-assisted instruction and teacher-directed instruction for handwriting. The students were given non-identifying letters for their identities to ensure

anonymity and protection during data collection and presenting the findings of the research study.

Findings

Data Analysis

Quantitative data analysis. The quantitative data collected from the Handwriting Proficiency Screener pre-assessment and post-assessment showed all but four students increased in their overall handwriting score. Three students decreased by 2-3 percentage points and were in the teacher-directed instructional group while the fourth student decreased by 8 percentage points and was in the technology-assisted instructional group. The student whom decreased by 8 percentage points had received the highest score on the pre-assessment compared to all students. Prior to the intervention, the technology-assisted instructional group had a mean score of 77 percent and the teacher-directed instructional group had a mean score of 76 percent. Figure 1 indicates that both instructional groups began with similar handwriting quality.

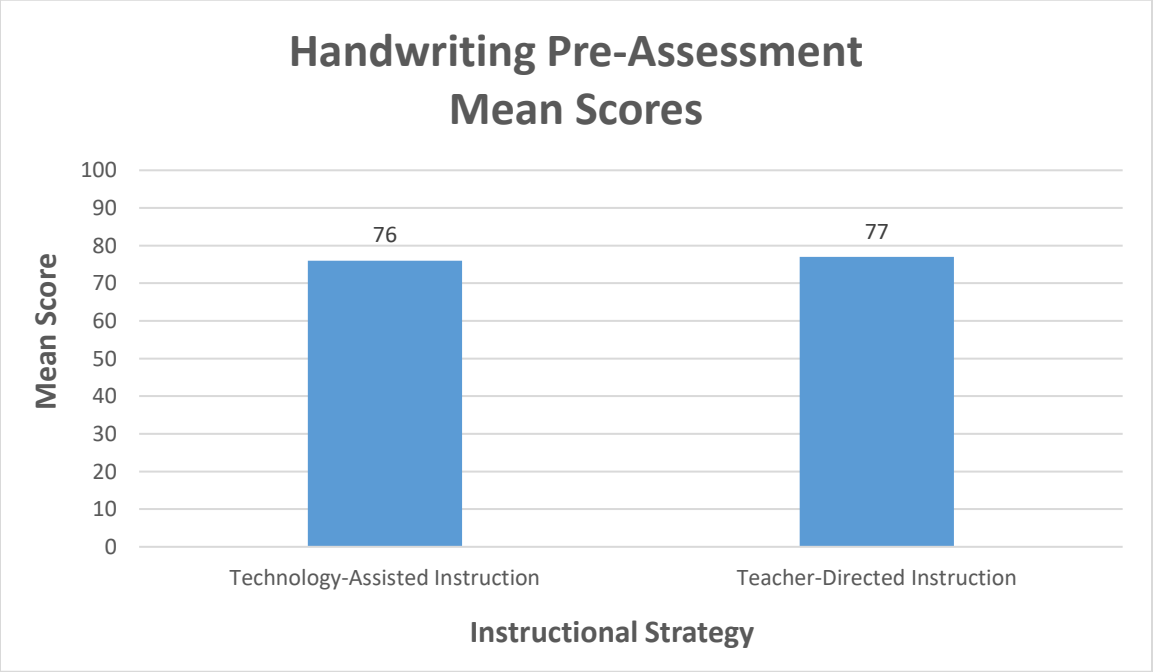

Figure 1. Comparison of pre-assessment mean scores for both instructional groups. The figure demonstrates that both groups had similar abilities before beginning the intervention.

Overall, students in the technology-assisted instructional group improved their handwriting composite score by 5 percent. The greatest gain was an improvement of 15 percent while the smallest was a decrease of 8 percent. Student B showed the greatest improvement and had the lowest score of all students in both instructional groups before the intervention began. Student H had a gain of 10 percent from the beginning to the end of the intervention period. An increase of 6 percent was demonstrated by Student L. Student M had an increase of 5 percent for their handwriting composite while Student D gained 4 percent by the end of the intervention period. Student J exhibited a handwriting composite score growth of 3 percent. One participant, Student C, in the technology-assisted instructional group showed a decrease of 8 percent and had originally scored the highest on the handwriting composite compared to participants from both instructional groups (Table 1, Table 2, and Figure 2).

Table 1

Technology-Assisted Instructional Group

Student	Pre-Assessment	Post-Assessment	Difference
Student B	67%	82%	+15
Student C	91%	86%	-8
Student D	71%	75%	+4
Student H	75%	85%	+10
Student J	76%	79%	+3
Student L	77%	83%	+6
Student M	80%	85%	+5
Group Mean	77%	82%	+5

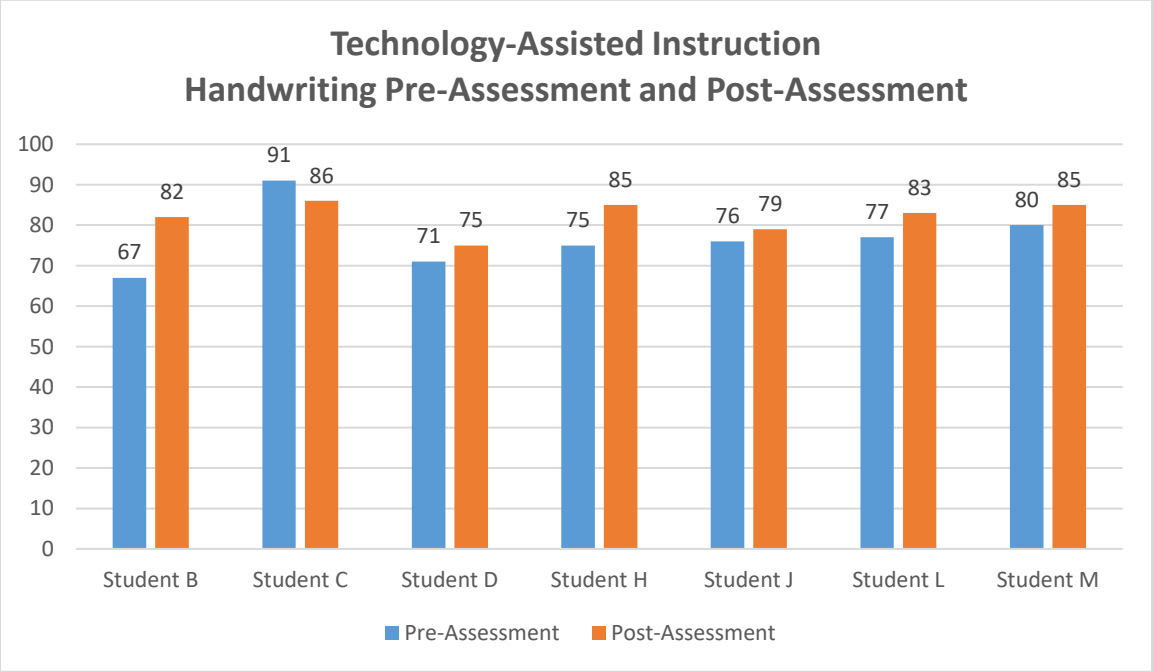

Figure 2. Technology-Assisted Instruction Group. This graph shows the scores of each student from the technology-assisted instruction group before and after the intervention.

Participants in the teacher-directed instructional group had a mean composite score growth of 7 percent. The greatest improvement was 18 percent and the lowest gain was a decrease of 3 percent. Two participants, Student E and Student K both showed a composite score increase of 18 percent. Student I gained 15 percent on the handwriting composite. Student A showed no increase or decrease in their composite score while three students showed a decrease. Student N decreased by 2 percent while Student F and Student G demonstrated a decrease of 3 percent for overall handwriting composite score (Table 2 and Figure 3).

Table 2

Teacher-Directed Instructional Group

Student	Pre-Assessment	Post-Assessment	Difference
Student A	83%	83%	0
Student E	75%	93%	+18
Student F	84%	81%	-3
Student G	78%	75%	-3
Student I	74%	89%	+15
Student K	72%	90%	+18
Student N	69%	67%	-2
Group Mean	76%	83%	+7

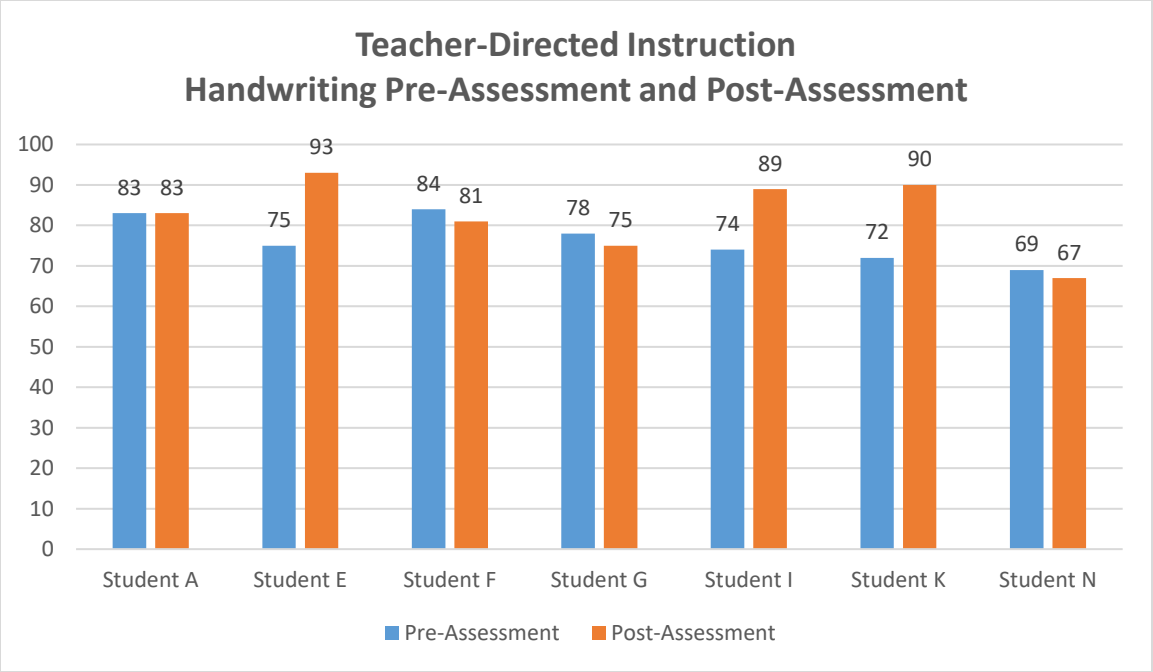

Figure 3. Teacher-Directed Instruction Group. This graph shows the scores of each student from the teacher-directed instruction group before and after the intervention.

For both the technology-assisted instructional group and the teacher-directed instructional group, the mean score increased for three of the four components. Orientation, placement, and sentence shown an improvement for both instructional groups, while the memory component decreased three points for the technology-assisted instructional group and one point for the teacher-directed instructional group. The sentence component was had the greatest improvement for the two instructional groups.

Table 3

Technology-Assisted Instructional Group and Teacher-Directed Instructional Group Break-Down of Scores

	Technology-Assisted Instruction		Teacher-Directed Instruction	
	Pre-Assessment	Post-Assessment	Pre-Assessment	Post-Assessment
Total Test Score	77	82	76	83
Component				
Memory	98	95	98	97
Orientation	90	94	90	94
Placement	75	80	79	83
Sentence	43	60	37	54

Discussion

Summary of Major Findings

The difference between the two instructional groups was very minimal with only a 1 percent difference of the composite scores. In addition, the four component scores also had only a slight difference in their results. The difference between each group is not statistically significant so the researcher cannot determine that technology-assisted instruction or teacher-directed instruction has a greater improvement rate in Kindergarten students' handwriting. The greatest area of improvement for both instructional groups was the sentence skills which consists of using a capital at the beginning, distinct lowercase letters, correct spacing between letters and words, and ending punctuation. The technology-assisted instructional group and the teacher-directed instructional group did not provide intervention on these sentence skills. However, these

skills were addressed in whole-group and small-group writing lessons throughout the school year which could have a possible effect on the sentence skill component of the results.

Limitations of the Study

Many limitations are present in the study that may have affected or influenced the interpretation of the findings on determining if technology-assisted instruction impacts the handwriting of Kindergarten students. The study included a total of 14 participants which were then divided into two groups which created extremely small sample sizes for each instructional group. Due to the small sample size, it is very hard to generalize the results to other Kindergarten students in other schools and areas of the United States. Another limitation that exists is the number of instructional weeks between the two administrations of the Screener of Handwriting Proficiency. According to Handwriting without Tears (2018), the screener is intended to be administered to students three times a year (beginning, mid-year, and end of year) allowing for about 10-12 weeks of instruction. However, this study allowed for four weeks of instruction, which is a considerable amount of time less than what is recommended. The shortened period of instruction could have affected the results of the study. In addition, the teacher acting as researcher is a limitation in the study. The teacher is aware of each students' individual needs, both academically and behaviorally. With this knowledge and awareness, teachers support students in different ways based on their needs which could influence the overall variables of the study and skew the results.

Further Study

The implementation and completion of the research study brought forth additional areas and questions to be studied further. The study utilized the handwriting app, Touch and Write. However, there are multiple other handwriting apps available, both free and paid. Further research could include a comparison study of multiple handwriting apps to determine if there is

an app that has a greater effect on handwriting quality. The Touch and Write app include multiple backgrounds to choose from that the participants discovered during the intervention. The background utilized was solid colored backgrounds, however it was discovered during the intervention that a background with handwriting lines was available. This background was not utilized in order to maintain the validity of the technology variable. The use of handwriting lines combined with technology-assisted instruction is an area for further study.

Another area for further study is increasing the number of instructional weeks during the intervention. Handwriting without Tears (2018) recommends that the Screener of Handwriting Proficiency be administered three times during the school year which allows for 10-12 weeks of handwriting instruction. In the current study, participants received four weeks of instruction. Increasing the instructional weeks could potentially have a positive effect on participants handwriting quality. The results may show a more significant difference between technology-assisted instruction and teacher-directed instruction regarding the handwriting of Kindergarten students.

Conclusion

Handwriting is the first step in students being able to express themselves through written text. It needs to be of good quality and legible for others to be able to read it. Quality handwriting for Kindergarten students includes correct formation, orientation of most letters and numbers correctly, grade-appropriate size, and placement on a base line (Handwriting without Tears, 2014). Handwriting is a prerequisite to writing, a significant component of the Common Core States Standards for students in Kindergarten through Twelfth Grade. This action research project explored the effect of two instructional approaches, technology-assisted instruction and teacher-directed instruction, on the handwriting quality of Kindergarten students. The

Kindergarten classroom participated in a four-week intervention where students were placed into two groups and each group received a different instructional approach for ten minutes a day. The results from the intervention were not statistically significant, but there was growth for both instructional groups. The technology-assisted instructional group demonstrated an increase of five points while the teacher-directed instructional group improved by seven points.

Previous research on technology-assisted instruction has shown to have positive effects on the improvement of academic skills, including the motivation of students. The students were very excited when it came time to use the iPads during the school day to practice their handwriting. The use of technology when it is not a constant mode of instruction for students made learning and practicing handwriting fun and engaging. In the same respect, students were eager to use whiteboards during handwriting instruction. Slight changes to everyday or weekly academic routines proved to be engaging for students and showed an improvement with their handwriting quality. While much more research is to be done on the effect of iPad apps for handwriting instruction, early childhood educators can be confident that incorporating iPads during handwriting instruction yields positive results.

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