

**The Impact of Occupational Therapy Involvement on Handwriting Acquisition for
Children: A Systematic Review**

Jamie Rosenberg Friedman

New York University

Abstract

Occupational therapists commonly address the challenges students have with handwriting but are largely not involved with initial handwriting instruction. This systematic review examines how the contribution of occupational therapy impacts handwriting acquisition for children learning to write. Through a comprehensive database search, this systematic review identified 24 studies that met inclusion criteria. These studies examined outcomes related to various handwriting interventions that are developed or provided by occupational therapists as compared with conventional classroom teacher instruction. The overwhelming evidence indicates that occupational therapy involvement with handwriting instruction significantly improves outcomes including handwriting readiness, handwriting speed, handwriting legibility, fine motor coordination, and far point copying (e.g., copying text from a blackboard). Evidence that emerged from the data has been categorized into five unique occupational therapy delivery approaches and labeled as follows: *Traditional*, *Teacher Implemented Occupational Therapy Curriculum (Teacher Implemented OT Curriculum)*, *Consultation*, *Team-Teaching*, and *Occupational Therapy Led (OT Led)*. The results suggest that direct occupational therapy involvement in handwriting acquisition delivered both reactively, after students have been identified with a handwriting difficulty, and proactively, for the entire class, improves handwriting and handwriting related outcomes. Specific curricula, dosages, and outcomes measured varied from study to study, therefore, confidence in the results of this review can be strengthened further by future research that examines common variables. Additionally, future research is needed that directly compares each identified delivery approach for efficacy and feasibility.

Key Words: Handwriting; Occupational therapy; Schools, Elementary

The Impact of Occupational Therapy Involvement on Handwriting Acquisition for Children: A Systematic Review

Handwriting is an essential and consequential occupation for children to master in the classroom environment. It is a student's earliest formal conduit for converting language into written form and is necessary for students to share knowledge (Connelly et al., 2007; Rogers & Case-Smith, 2002). Handwriting has been defined as the ability to produce writing legibly and swiftly (Dinehart, 2014). Legibility refers to the neatness or precision of the text. It includes accurate letter formation, directionality, size, and alignment, which relates to the spacing between letters and words as well as their placement on the line (Feder & Majnemer, 2007; Lifshitz & Har-Zvi, 2014). Speed is the temporal aspect of handwriting and is measured by the amount of text that is produced in a specific time period (Prunty et al., 2013). Three factors establish speed: first, the duration of the task or the time from initiation of the writing task to its completion; second, the speed of execution or the pace at which the pencil is moving when in contact with the paper; and third, the duration of time spent paused which is measured as the percentage of time during the task when the pencil is either not in contact with the paper or not moving on the paper (Prunty et al., 2013).

Handwriting skill is considered to be proficient when text can be produced legibly and with a minimum of effort (Rosenblum et al., 2006). Proficient handwriting incorporates the coordination of cognitive, motor, and perceptual skills (Lifshitz & Har-Zvi, 2014; Maldarelli et al., 2015). Developing aptitude in handwriting, or handwriting acquisition, has been associated with enduring academic outcomes in math, reading, and composition (DaVanzo, 2018; Dinehart, 2014; McCarroll & Fletcher, 2017). Researchers have found that fine motor skills developed specifically when using a writing utensil to copy letters and numbers, imitate strokes, and draw,

were consistently stronger predictors of reading and math achievement than fine motor manipulation tasks developed, for example, when building with blocks or cutting with scissors (Dinehart & Manfra, 2013; Son & Meisels, 2006). Researchers have also linked handwriting acquisition to letter recognition, an important preliteracy skill for children as they prepare to become readers (Longcamp et al., 2005; James & Engelhardt, 2012). In a study published in 2005, Longcamp et al., found that preschoolers who practice printing words using a writing utensil significantly outperformed preschoolers who typed the same words using a keyboard on a posttest letter recognition task. The authors surmised that writing may have helped develop a stronger internal model of the letters (Longcamp et al., 2005). James and Engelhardt (2012) add that it is the unique experience of learning to write letters, “stroke by stroke, [that] helps children understand the important components that define a letter” (p. 16).

Just as proficient handwriting has been correlated with academic achievement, difficulty producing legible writing fluently, has been associated with adverse academic outcomes. Learning to write letters is a complex task. It requires the novice to cognitively access the letter form, attend to placement on the page or line, the starting position of the first stroke, the sequence of strokes, and the direction of strokes that are used to complete the letter. These actions require a substantial cognitive demand for beginning writers until the skill becomes automatic and no longer requires conscious attention (McCutchen, 1996; Medwell, Strand, & Wray, 2009). Students having difficulty gaining such automaticity, continue to draw cognitive capacity away from composition content in order to generate legible letters (Medwell & Wray, 2014). Lack of automaticity not only demands more effort from the student, in practice, it also reduces the speed and ultimately the amount of text a student can produced during timed assignments (Medwell & Wray, 2007). Research suggests that automaticity is the single best

predictor of length and quality of written composition throughout the student's education years (Connelly et al., 2007; Graham, Berninger et al., 1997).

Moreover, poor handwriting skills may manifest in decreased legibility and lead to lower grades. When an assignment is difficult to decipher, a teacher may not read a portion of the text and therefore, assign a grade that is based on incomplete information (Santangelo & Graham, 2016). Lee and Lape (2020) further describe that "when an assignment is illegible, teachers may interpret the written responses incorrectly which results in lower grades" (p. 171). Additionally, judgements regarding the quality of the content can be biased by the teacher's perception of the student's capabilities based on the legibility of the writing (Santangelo & Graham, 2016). Researchers have found that teachers tend to award higher grades to assignments that are attractive and easier to read even when given explicit instructions to grade solely on content (Greifeneder et al., 2010). In either case, the student's true abilities are not accurately reflected by the grade assigned.

These adverse results can take a toll on developing writers. Researchers have taken note of the social-emotional impact for students who struggle with poor handwriting. Limpo and Graham (2020) suggest that handwriting difficulty "may turn the act of producing text into an arduous and eventually distressing experience" (pp. 316-317). Students who experience frustration with handwriting may consequently develop negative attitudes about writing and try to avoid completing assignments (Lifshitz & Har-Zvi, 2014). Furthermore, students are often aware of their handwriting difficulties which results in low self-esteem and reduced participation in classroom activities (Engel-Yeger et al., 2009). In total, these outcomes suggest the importance of handwriting proficiency and addressing effective handwriting instruction.

Historical Trends of Handwriting Pedagogy

In the United States, elementary school teachers are entrusted with the responsibility of initial handwriting instruction. Historically, handwriting has been considered an essential skill for children to acquire and use throughout their school years (Donica et al., 2012; Graham & Weintraub, 1996, Lee & Lape, 2020). Up until the 1970s, handwriting, or penmanship, was taught as an individual lesson from first to sixth grade and received its own grade on a student's report card (Blazer, 2010). More recently however, the importance of handwriting instructions in elementary school education has waned (Collette et al., 2017). As handwriting is a motor skill, it requires ample practice after initial instruction for optimal learning (Graham & Weintraub, 1996; Guadagnoli & Lee, 2004). However, current trends indicate reduced instruction and practice times in the classroom (Collette et al., 2017, Donica et al., 2012; Graham et al., 2003).

Researchers have proposed multiple reasons for this trend. Often mentioned is the effect of Common Core State Standards (CCSS) on teaching practices (Collette et al., 2017; Donica et al., 2012; Nye & Sood, 2018). Conspicuously, this codified set of benchmarks used in the United States for teaching and testing English and Math in kindergarten through twelfth grade, does not directly mention handwriting (National Governors Association Center for Best Practices, 2021). Asher & Estes, (2016) noted that teachers tend to focus classroom time on "subjects that students will be tested on" (p. 360). Collette et al., (2017) also found that teachers from kindergarten to second grade felt that CCSS "increased requirements in other areas, resulting in insufficient or no time for handwriting instruction" (p. 5). Furthermore, with the increasing availability of computers in the classroom, there has been a natural shift from hand-written to computer-based assignments (including state testing), and a subsequent decline in the priority of handwriting instruction (Asher & Estes, 2016; Cahill, 2009).

Examining teachers' perceptions on handwriting instruction is valuable to understanding how handwriting is taught to developing writers. Importantly, a 2008 survey found that a mere 12% of participating teachers felt that they received adequate preparation in their college education courses to teach handwriting (Graham et al., 2008). In a survey published ten years later, Nye and Sood (2018) continued to find that kindergarten and elementary teachers desired further formal education on acquisition of developmental skills and identifying handwriting-related difficulties. Even with this dearth of consistent formal education, teachers are responsible for implementing and sometimes developing handwriting curriculum (Asher, 2006; Donica et al., 2012). Currently, there is no one handwriting instruction model or curriculum that spans across schools and across grades. Educators have reported using a multitude of inconsistent methods (such as when handwriting instruction should begin, practice schedules, and letter order for initial instruction), tools (various shaped pencils and grips, and differently lined papers), and curricula to teach handwriting (Asher, 2006, Donica et al., 2012). Even within school systems, Asher (2006) found an absence of continuity of instruction noted between grade levels. It has been speculated that the sparsity of formal education on handwriting for teachers and inconsistencies in the process of instruction, can potentially limit the effectiveness of handwriting instruction and lead to handwriting difficulties for students (Asher, 2006).

Occupational Therapy and Evidence-Based Handwriting Intervention

Whether handwriting dysfunction emerges due to inadequate or inconsistent instruction, or if it arises due to an impairment or delay in cognitive, motor, or perceptual skills, it has been estimated that up to 33% of school age children exhibit handwriting difficulties (Feder & Majnemer, 2007; Smits-Engelsman et al., 2001). When handwriting difficulties are identified in the classroom, occupational therapy services are often referred. Occupational therapists are

uniquely positioned to effectively contribute to handwriting acquisition. Occupational therapists are experts in analyzing meaningful occupations, identifying underlying performance skill deficits that contribute to handwriting difficulties, and providing evidenced-based interventions or adaptations. Occupational therapists also harbor important knowledge about social and psychological behavior, motor learning theory, and child development. Such skills, Donica (2010) suggests, “empower occupational therapists to evaluate and treat children with handwriting challenges” (p. 46).

Occupational therapists have traditionally approached handwriting intervention with either a bottom-up (multisensory, sensorimotor) or top-down (cognitive, task-oriented, therapeutic practice) process or a combination of the two (Cramm & Egan, 2015; Case-Smith, Weaver, & Holland, 2014; Weintraub et al., 2009). The focus of the bottom-up approach is to practice the foundational performance components of handwriting, including sensory integration, visual perception, motor coordination, and pencil grip (Cramm & Egan, 2015; Case-Smith, Holland, & White, 2014, Piller & Torrez, 2019). With this approach, students practice sensory-motor skills through occupations that involve visual-motor integration, haptic and visual perception, and fine motor coordination (Case-Smith, Weaver, & Holland, 2014). The top-down approach focuses on the occupational performance of handwriting and uses cognitive strategies and practice to gain proficient handwriting skills (Cramm & Egan, 2015). Here, students extensively and systematically practice letter formation with copious amounts of support and explicit instruction (Case-Smith, Weaver, & Holland, 2014). This approach stresses feedback, peer modeling, student problem solving, and self-evaluation (Weintraub, et al., 2009). While recent researchers have questioned the potential efficacy of bottom-up approaches, it remains uncertain which strategy is most effective for specific handwriting challenges, at what dosage,

and the potential efficacy of combining methodologies (Cramm & Egan, 2015; Denton et al., 2006; Howe et al., 2013; Piller & Torrez, 2019; Pfeiffer, Moskowitz, et al., 2015; Zwicker & Hadwin, 2007; Zylstra & Pfeiffer, 2016).

The bottom-up approach was popular among school-based occupational therapist at the turn of this century. A survey published in 2002 found that 92% of occupational therapists employed “multisensory modalities and activities in handwriting remediation” (Woodward & Swinth, 2002, p. 305). More recently, Piller and Torrez (2019) found that occupational therapists from a single site also favor the bottom-up approach (54%). Unfortunately, this finding is highly ungeneralizable. Although it is difficult to determine en masse the precise interventions utilized in daily practice, this information would greatly benefit our understanding of the efficacy of various interventions.

Keeping these methods in mind, occupational therapists can also choose among multiple commercial handwriting curricula, various lined papers, and pencil sizes and grips. First, among the most widely researched handwriting curriculum developed by occupational therapists in the United States in the past two decades are Handwriting Without Tears (HWT; Olson, 2003; Olsen, et al., 2008), Size Matters Handwriting Program (SMHP; Moskowitz, 2009), and Write Direction (Taras, et al., 2011). A recently published systematic review examined the efficacy of these programs (Engle et al., 2018). The authors found that while the use of all curricula improved handwriting outcomes (i.e., legibility, speed, and automaticity), “no one handwriting program appeared to outperform the other programs across all domains” (p. 6). Next, there are numerous types of paper promoted by different handwriting curricula that offer various characteristics including, raised or highlighted lines, dashed midlines, and various widths between lines. Research, although sparse and dated, suggests that for kindergarteners, the width

of the lines (one inch or one-half inch) “had no differential effect on the quality of beginning handwriting” (Halpin & Halpin, 1976). Furthermore, Daly et al., (2003) found that for kindergarteners, the use of paper with or without lines was not related to handwriting legibility. For students in first grade, however, research found that wider-lined paper that supplies both top and bottom guideline can influence the size of the written letter (Reidlinger et al., 2012). The research on the value of various pencil sizes and shapes is similarly limited and dated. Generally, researchers have found that for elementary students, the size, shape, and diameter of the pencil did not impact graphomotor control (Carlson & Cunningham, 1990; Oehler et al., 2000; Ziviani, 1981). Finally, the dynamic tripod grasp, a mature grasp pattern that involves the integration of both intrinsic and extrinsic muscles of the hand, has traditionally been viewed as superlative in regard to handwriting legibility or speed. (Donica et al., 2018; Schneck & Henderson, 1990). However, research has not consistently supported this view (Koziatek & Powell, 2003; Schwellnus et al., 2013; Donica et al., 2018). Therefore, Donica et al., (2018) warn that “it may not be appropriate to attempt to change the grasp pattern solely based on the preconceived notion that an atypical grasp pattern includes all grasps other than the dynamic tripod” (p. 423). Overall, continued research is needed to confirm best practices regarding grasp patterns, tools, and curricula.

Current Trends and Research: The Evolving Role of School-Based Occupational Therapy

According to Cahill et al., (2014), the traditional role of school-based occupational therapy has been evolving in reaction to the Response to Intervention (RtI) provision in the 2004 reauthorization of the Individuals with Disabilities Education Improvement Act (IDEA). RtI is a team-based, student centered, multitiered service delivery system that proactively initiates appropriate, evidence-based instruction built on academic and behavioral needs (Ohl et al.,

2013). Tiers are designated by the size of the student population served and the intensity of the interventions provided. Tier 1 reaches the greatest number of students, schoolwide or whole-classroom, and provides the least intensive interventions (Ohl, et al., 2013). The second and third tiers incorporate smaller groups and individualized interventions.

Current literature suggests that occupational therapists are providing services at all tiers of RtI (Cahill et al., 2014). Traditionally, occupational therapists provide handwriting remediation services with individualized interventions in response to an identified handwriting difficulty. However, researchers are more recently examining the benefits of incorporating and embedding occupational therapy proactively for all students in the classroom during initial handwriting instruction (Case-Smith, Weaver, & Holland, 2014). Such delivery approaches take on multiple forms including the provision of occupational therapy developed curricula, occupational therapy consultation or collaboration with classroom instructors, and direct autonomous occupational therapy instruction. As the dynamics of occupational therapy delivery of services shifts in response to RtI, it is important to reappraise the efficacy of traditional and emerging approaches to handwriting instruction and intervention. Currently, there is a lack of research that compares the impact of the various levels of participation which occupational therapists employ when providing handwriting intervention, with the conventional approach of teacher led instruction.

Other recently published systematic reviews on handwriting acquisition have examined the efficacy of various handwriting interventions employed specifically by occupational therapists (Engel et al., 2018; Fancher et al., 2018; Grajo, Candler, & Sarafian, 2020; Hoy et al., 2011; Kadar, et al., 2020). Hoy, et al.(2011) concluded that handwriting intervention must incorporate handwriting practice at least twice a week for 20 sessions in order to be effective;

Engel, et al. (2018), established that although curriculum-based handwriting programs effectively address legibility, no one program exhibited supremacy across domains (speed, legibility, and fluency); Fancher, et al., (2018), verify the complexity of handwriting by examining neural imaging literature associated with letter identification and handwriting interventions; Kadar, et al., (2019), found, generally, that in regards to handwriting skills, preschool children benefit from occupational therapy interventions; and Grajo et al., (2020), determined that interventions addressing handwriting prerequisite skills must be linked to a handwriting task and will not render improved handwriting in isolation. These systematic reviews are important, yet these reviews are limited as they only examine the efficacy of handwriting interventions employed by occupational therapists in isolation of typical classroom teacher-led instruction. As school-based occupational therapy services continue to evolve and integrate in response to RtI, it is necessary to understand how our participation effects handwriting acquisition. Therefore, the objective of the current systematic review is to examine the impact of occupational therapy involvement on student handwriting acquisition as compared with handwriting instruction that is conventionally provided by schoolteachers.

Methods

Search Strategy

A systematic search of the literature was conducted to identify studies that addressed the impact of occupational therapy involvement on handwriting acquisition skills. The search strategy was initiated by using the following Population, Intervention, Comparison, Outcome (PICO) question: How does occupational therapy involvement in handwriting acquisition impact handwriting outcomes for students learning to write compared to conventional teacher-led instruction? For the purposes of this review, occupational therapy involvement indicates that an

occupational therapist or occupational therapy student, is either the developer of a curriculum or model, or the provider of handwriting intervention; conventional teacher-led instruction will indicate that occupational therapy is not involved with student handwriting acquisition.

The current review included studies of occupational therapy handwriting interventions published from March 2001 to August 2021. Although many systematic reviews examine research published in the most recent previous decade, this author chose to widen the search in order to examine the progression of occupational therapy involvement in handwriting acquisition prior to RtI until now, develop a more comprehensive analysis, and include more level I studies to strengthen the results of this review.

The following databases were searched: ERIC, CINHAL, Pub Med, Google Scholar, the American Journal of Occupational Therapy, the Journal of Occupational Therapy, Schools, and Early Intervention, and hand searches of reference lists. The terms used in the search were an attempt to capture relevant articles. Search terms initially included: handwriting, dysgraphia, handwriting difficulties or impairments or dysfunction, handwriting acquisition, handwriting intervention, handwriting programs, occupational therapy, occupational therapy intervention, school-based occupational therapy, students, preschool, kindergarten, first grade, second grade and elementary school. The most productive searches included the search terms “occupational therapy” and “handwriting.”

Inclusion and Exclusion Criteria

In order to determine the of impact occupational therapy involvement on handwriting acquisition compared with conventional classroom instruction, studies were included if they met the following criteria: 1) studies examined occupational therapy involvement in handwriting intervention as the experimental condition and conventional teacher-led instruction as the control

condition; 2) studies concentrated on the years when children typically learn handwriting fundamentals (preschool through elementary, or ages 4 through 10); 3) studies were published in scientific peer reviewed literature; 4) a quantitative study design was implemented; and 5) Studies were published in English. Studies completed in non-English speaking countries were only included if they were published in English. It is important to recognize the process of handwriting instruction in other countries as there are different handwriting curricula and models utilized. Discerning these differences allows for a deeper appreciation of the fundamental skills required for handwriting acquisition and also the similarities and differences in the handwriting instruction process. Studies were excluded if: 1) studies did not include conventional teacher-led instruction as the control condition; 2) studies involved adults or children relearning handwriting after an illness or injury; 3) studies addressed the impact of misspelling on readability (which lies in the domain of education and not occupational therapy intervention) rather than the impact of text neatness or legibility; and 4) studies addressed the student's comprehension of the text during handwriting (such as copying text or notetaking).

Critical Appraisal

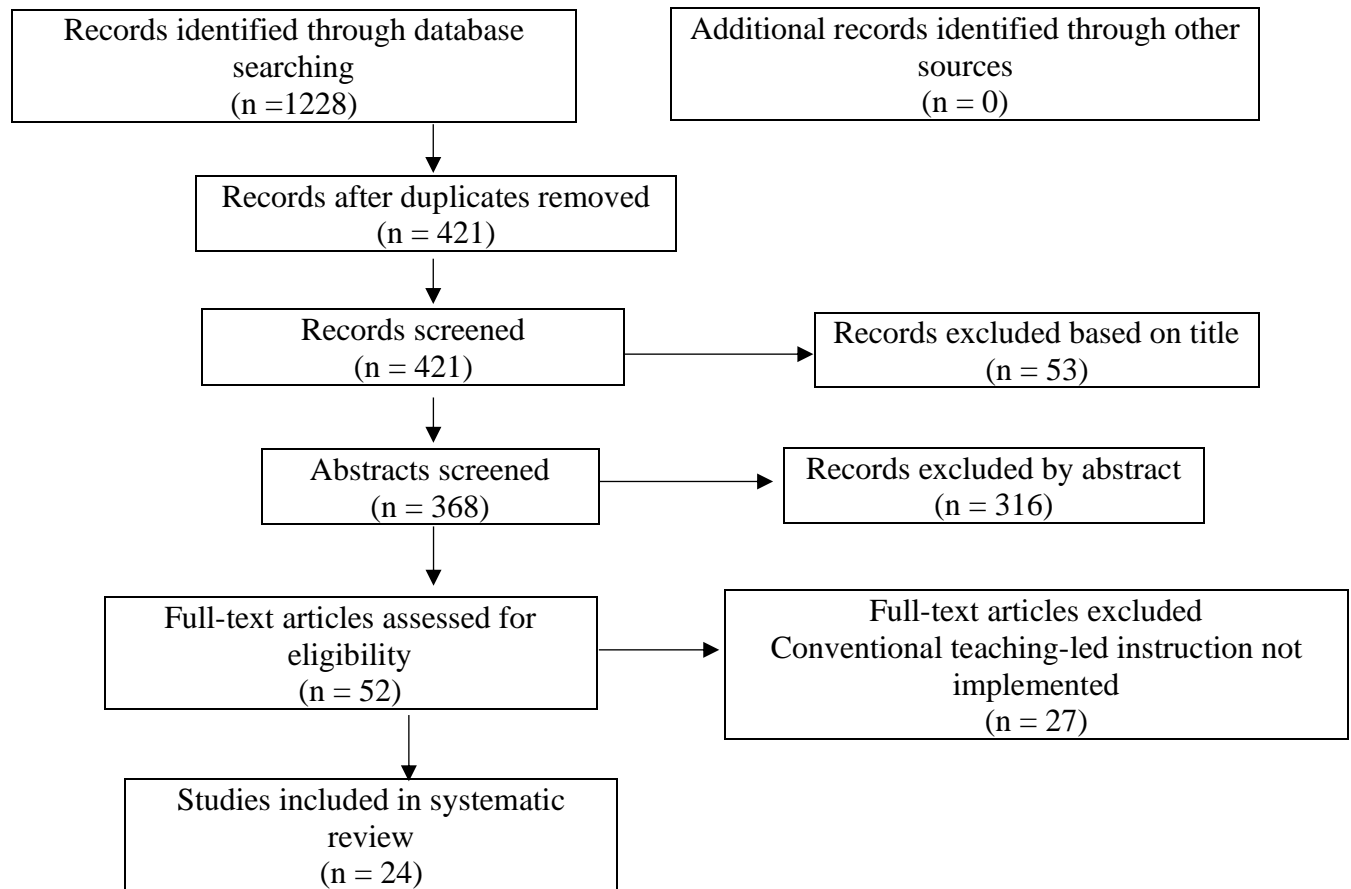
The author of this systematic review independently conducted the screening and selection of the retrieved studies, appraised quality, and extracted the data. Each study was critically appraised to assess quality by using the Quantitative Review Form and guidelines developed at McMaster University (Law & McDermid, 2014). A level of evidence was assigned using Occupational Therapy Association's (OTA) Level of Evidence table that designates strength according to study design with level I indicating the strongest level of evidence of the causality of the intervention to the outcome, and level V indicating the weakest level of evidence. The strength of the evidence was further determined by applying the OTA's Strength of Evidence

tables which designates level of certainty as strong, moderate, or low, based on quantity of high-quality studies (AOTA, 2017). Risk of bias was assessed for this study using the guidelines outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins & Green, 2011).

Results

Selection Identification

Initial search strategies yielded a total of 421 articles matching the search terms. Of these articles, 53 were excluded because the titles indicated that they were unrelated to the research question. Studies were removed from consideration for the following reasons: 1) the participants were adults or children relearning handwriting; 2) studies examined how specific learning differences or impairments effect handwriting acquisition; 3) the articles were surveys, systematic reviews, or qualitative; 4) studies addressed keyboarding; and 5) studies assessed the psychometric properties of specific handwriting evaluations. Of the remaining 368 articles, 316 were excluded after screening the abstracts and an additional 27 articles were excluded after reading the full texts. These articles were excluded either because occupational therapy involvement in the intervention was absent from the study or the control group did not use conventional teacher-led instruction (e.g., only occupational therapy generated interventions were examined). As a necessary determinant, all studies in this systematic review included occupational therapy involvement in handwriting acquisition in the intervention group and conventional teacher-led instruction in the control group. Finally, the studies include a variety of occupational therapy delivery approaches, methods of instruction, and curricula. Figure 1 shows the number of studies identified, screened, eligible for, and included in the systematic review.

Figure 1*Flow Diagram***Risk of Bias, Levels of Evidence, and Strength of Evidence**

Risk of bias was assessed for this study using the guidelines outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins et al., 2011). Levels of evidence were assigned using AOTA guidelines (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). The strength of the evidence was evaluated based on the guidelines from the U.S. Preventive Service Task Force (1996). Six level I studies were included in this systematic review (Chang & Yu, 2017; Denton et al., 2006; Peterson & Nelson, 2003; Ratzon et al., 2007; Weintraub et al., 2009; Zwicker & Hadwin, 2009). Of the six, five were deemed to have low risk for bias because

they utilized random assignments, reported attrition, and self-reported bias (Denton et al., 2006; Peterson & Nelson, 2003; Ratzon et al., 2007; Weintraub et al., 2009; Zwicker & Hadwin, 2009). Chang and Yu (2017), Denton et al., (2006), Peterson and Nelson (2003), and Zwicker and Hadwin (2007), note that in their studies, the intervention groups received more attention than the control groups. The remaining 18 Level II studies were cohort studies and lacked random assignment (Case-Smith, 2002; Case-Smith, Holland, & White, 2014; Case-Smith, Weaver & Holland, 2014; Chandler, et al., 2014; Donica, 2015; Donica, Goins, & Wagner, 2013; Donica, McCraw et al., 2013; Zylstra & Pfeiffer, 2016; Hape, et al., 2016; Hunter & Potvin, 2019; Jordon et al., 2016; Kaiser et al., 2011; Lust & Donica, 2011; Pfeiffer, Rai et al., 2015; Pfeiffer, Moskowitz, et al., 2015; Roberts et al., 2014; Schneck et al., 2002; Taras et al., 2011; Weintraub et al., 2009). Most of the studies had limited or no blinding (scoring outcomes were blinded but not the administration). Table 1 summarizes the studies' risk of bias (see Table 1).

Data Extraction

The aim of this systematic review was to examine the impact of occupational therapy involvement in handwriting acquisition compared to conventional handwriting instruction provided by classroom teachers. Therefore, key data to be extracted from the studies included type of interventions provided, intensity and frequency of the dosage, outcomes measured, delivery approach of occupational therapy involvement (developer of the curriculum, provider of the intervention, amount of collaboration between teacher and occupational therapist), as well as characteristics of the control condition. Information significant to the PICO question was extracted and organized in the Evidence Table (see Table 2).

Selection Summary

In all, 24 (6 level I and 18 level II) articles were located that examined the impact of occupational therapy involvement in handwriting acquisition compared with conventional teacher-led instruction. The vast majority, 23, found that when occupational therapists were involved, student's handwriting skills improved more than when classroom teachers conventionally provided handwriting instruction alone. Twenty of these studies found statistically significant improvements in areas such as handwriting readiness (Lust and Donica, 2011), handwriting speed (Case-Smith Weaver, & Holland, 2014; Kaiser et al., 2011), handwriting legibility (Case-Smith, 2002; Case-Smith, Weaver, & Holland, 2014; Case-Smith, Holland, & White, 2014; Chandler et al., 2014; Denton et al., 2006; Donica, 2015; Donica, McCraw, Hudson, & Carson, 2013; Jordan et al., 2016; Kaiser et al., 2011; Peterson & Nelson 2003; Pfeiffer, Moskowitz et al., 2015; Pfeiffer, Rai, et al., 2015; Roberts et al., 2014; Schneck et al., 2012; Taras et al., 2011), handwriting fluency (Case-Smith, Holland, & White, 2014); fine motor coordination (Lust & Donica, 2011; Ratzon et al., 2007) and visual skills and far point copying (Chang & Yu, 2017). These results, summarized in Table 2, suggest strong evidence supporting the involvement of occupational therapy in handwriting acquisition for children learning to write compared with conventional teacher-led instruction (see Table 2).

Occupational Therapy Delivery Approaches to Handwriting Intervention

To further summarize the results, studies are grouped into themes related to the occupational therapy delivery approach applied in the intervention. In all, five delivery approaches emerged and are categorized and labeled by the author of this review. First, the *Traditional* approach involves teacher instruction with occupational therapy involvement only after students are identified as exhibiting difficulty with handwriting. In this approach, students are either pulled-out of the classroom for occupational therapy services or participate in

occupational therapy outside of the school setting (e.g., private practice). The second delivery approach, *Teacher Implemented OT Curriculum*, is similar to the Traditional approach in that it employs teacher-led handwriting instruction. However, in this approach teachers use a curriculum that was developed by occupational therapists. These curricula provide teachers with instructions on how to teach handwriting including letter sequence and verbiage to use during instruction. Often commercially available, these curricula offer courses for certification, student workbooks, lined paper, and other handwriting paraphernalia such as pencils, chalk and chalkboards, related games, and access to computer instruction (see Table 3 for summaries of occupational therapy developed curricula). The third delivery approach, *Consultation*, is defined by the supportive role of the occupational therapist. With this approach, classroom teachers provide handwriting instruction with consistent occupational therapy participation. Occupational therapists are consulted for assistance with instruction and are available in the classroom at regular intervals to observe students' progression. The fourth delivery approach, *Team-Teaching*, employs occupational therapists embedded into the classroom during handwriting instruction. With this proactive approach, occupational therapists coteach alongside the classroom teacher and often with an intervention specialist or a trained educational assistant, as well. All members of the handwriting team provide their expert knowledge in a unified and consistent manner. In the last delivery approach, *OT Led*, occupational therapists conduct handwriting instruction to all students with or without an identified handwriting difficulty. This approach either replaces the responsibility of handwriting instruction from the classroom teacher to the occupational therapist or combines separate and discrete handwriting instruction (both in terms of times provided and instruction techniques) from both an occupational therapist and a classroom teacher. Notably,

this approach emerges based on the scientific designs of the studies and is absent from current literature as a real-world application.

Data Synthesis of Occupational Therapy Delivery Approaches

Traditional Approach

Six studies (5 level I, 1 level II) with low risk of bias, employed the Traditional approach for service delivery (Case-Smith; 2002; Chang & Yu, 2017; Denton et al., 2006; Ratzon et al., 2007; Weintraub et al., 2009; Zwicker & Hadwin, 2009). All participants, students between first grade and fourth grade, had been identified by teachers or physicians as exhibiting handwriting difficulties. Most of the studies describe a conventional pull-out routine in which occupational therapy services are implemented separately from classroom instruction during the school day. In one study, occupational therapy services were provided after school and separate from school (Weintraub, et al., 2009). Although the Traditional delivery approach was a constant commonality among these studies, interventions ranged in dosage (frequency and length) and process (bottom-up, top-down, or a combination). Interventions are summarized in the Evidence Table (See Table 2).

Strong evidence from four level I studies and one level II study, supports the Traditional delivery approach of handwriting intervention above conventional teacher-led instruction for improvements in handwriting performance and performance components in the areas of legibility (Case-Smith, 2002; Denton et al., 2006; Weintraub et al., 2009), graphomotor and fine motor control (Ratzon et al., 2007), visual-motor skills and far point copying (Chang & Yu, 2017) for students with identified handwriting impairments. A level I study found that first and second-grade students exhibited an improvement in handwriting legibility when the Traditional approach was implemented. However, the improvement was not statistically significant when compared

with conventional classroom teacher-led instruction (Zwicker & Hadwin, 2009). Evidence from studies using this delivery approach did not find a significant impact on handwriting speed.

Teacher Implemented OT Curriculum

Only one level II study involved the Teacher Implemented OT Curriculum delivery approach (Hunter and Potvin, 2019). These researchers examine the efficacy of teachers implementing the Size Matters Handwriting Program (SMHP) compared with the conventional class instruction. Hunter and Potvin (2019) found that kindergarteners, both in classrooms where teachers used an occupational therapy developed curriculum and kindergarteners in classrooms where teachers did not, improved significantly in terms of legibility from the beginning of the school year to the end. The authors did not find, however, a statistically significant difference between the two groups of kindergarteners.

Consultation

Nine studies (level II) describe the use of a Consultation delivery approach (Chandler et al., 2014; Donica, 2015; Donica, McCraw et al, 2013; Hape et al., 2014; Jordan et al., 2016; Pfeiffer, Moskowitz et al., 2015; Pfeiffer, Rai et al., 2015; Roberts et al., 2014; Schneck et al., 2012). Two studies, published separately with varying authors, used the same samples and data to answer distinct research questions (Pfeiffer, Moskowitz et al., 2015; Pfeiffer, Rai et al., 2015). Pfeiffer, Moskowitz et al., (2015), examine the suitability of an assessment of visual-motor skills, the Berry-Buktenica Developmental Test of Visual-Motor Integration, as an outcome measure for handwriting interventions. Pfeiffer, Rai et al., (2015), assess the effectiveness of the Size Matters Handwriting Program for improving handwriting legibility.

All studies using the Consultation approach were completed in general education classrooms. The amount of time that occupational therapists provided in-class consultation

varied from multiple times a week to bimonthly or less. In the studies, occupational therapists delivered services through the Consultation approach by teaching the handwriting lesson for the day, being present during the handwriting lessons, creating the lesson plans for teachers to utilize, support and answering teacher's questions, and "close collaboration" through email. Notably, one study completed in Switzerland, only provided consultation through emails as the country did not use school-based occupational therapists at the time of publication (Jordan et al., 2016).

Moderate evidence from five of the studies showed significant improvements in handwriting legibility for preschool and kindergarten students when a Consultation approach was implemented compared to conventional teacher-led instruction and therefore, supports the effectiveness of this approach for handwriting intervention in preschool and kindergarten (Chandler et al., 2014; Donica, 2015; Donica, McCraw et al., 2013; Pfeiffer, Moskowitz et al., 2015; Pfeiffer, Rai et al., 2015). There is moderate evidence from six of the studies with mixed results suggesting the efficacy of Consultation approach with first and second-grade students (Hape et al., 2014; Jordan et al., 2016; Pfeiffer, Moskowitz et al., 2015; Pfeiffer, Rai et al., 2015; Roberts et al., 2015; Schneck et al., 2015). Four of these studies found significant improvement in handwriting legibility with occupational therapy involvement using the Consultation approach compared with conventional teacher-led handwriting instruction (Jordan et al., 2016; Pfeiffer, Moskowitz et al., 2015; Pfeiffer, Rai et al., 2015; Roberts et al., 2015). The data in Hape et al., (2014), show that in classrooms that utilized the Consultation approach with first grade students, handwriting outcomes improved more than conventional teacher-led approach. However, while the outcomes were higher, this finding was not statistically significant. Schneck et al., (2015), found that the control group scored significantly higher than the intervention group that

employed the Consultation approach. The Evidence Table summarizes the studies' findings (See Table 2).

Team Teaching

A Team-Teaching delivery approach was implemented in four (level II) studies (Case-Smith, Weaver, & Holland, 2014; Case-Smith, Holland, & White, 2014; Lust & Donica, 2011; Zylstra & Pfeiffer, 2016). Within these studies, the occupational therapists were embedded in the classrooms during all handwriting lessons. Classroom teachers, occupational therapists, and education specialists shared the responsibility of handwriting instruction for students with and without identified handwriting difficulties. Interventions used in these studies ranged in dosage and methodology (See Table 2).

Moderate evidence supports the use of the Team-Teaching approach in preschool, kindergarten, and first grade for improving handwriting outcomes compared with conventional teacher-led handwriting instruction (Case-Smith, Holland, & White, 2014; Case-Smith, Weaver, & Holland, 2014; Lust & Donica, 2011; Zylstra & Pfeifer, 2016). Significant improvements were noted in handwriting speed and handwriting legibility (Case-Smith, Holland, & White, 2014, Case-Smith, Weaver, & Holland, 2014), handwriting readiness and fine-motor skills (Lust & Donica, 2011), and handwriting legibility (Zylstra & Pfeifer, 2016).

OT Led

Four studies (1 level I and 3 level II) fall under the category of the OT Led delivery approach (Donica, Goins et al., 2013; Kaiser et al., 2011; Peterson & Nelson, 2003; Taras et al., 2011). These studies describe occupational therapists providing handwriting instruction to all students both with and without noted handwriting difficulties. Participants include students in Head Start, kindergarten, and first grade.

Strong evidence from three studies (1 level I and 2 level II) supports the use of the OT Led approach for use with students in both kindergarten and first grade compared with conventional teacher-led instruction (Kaiser et al., 2011; Peterson & Nelson, 2003; Taras et al., 2011). These studies found significant improvement in handwriting legibility when handwriting instruction was provided proactively and autonomously by occupational therapist when compared to conventional classroom instruction (Kaiser et al., 2011; Peterson & Nelson, 2003; Taras et al., 2011). Data from a level II study found that with the OT Led delivery approach, students improved handwriting related skills more than students only receiving the teacher-lead Head Start programing, however, this improvement was not statistically significant (Donica, Goins, et al., 2013). The Evidence Table summarizes each studies' results (see Table 2).

Discussion

The aim of this systematic review is to examine the impact of occupational therapy involvement on handwriting acquisition skills as compared with handwriting instruction that is conventionally provided in the classroom by teachers. Overall, the results favorably support the involvement of occupational therapy in handwriting acquisition for students learning to write as compared with conventional teacher-led instruction. The results indicate that when occupational therapists contribute to the process of handwriting instruction, there is a significant added benefit in handwriting readiness, handwriting speed, handwriting legibility, fine motor coordination, and far point copying. This is consistent with evidence from previous research that demonstrates that the interventions employed by occupational therapists improve handwriting outcomes (Howe et al., 2013; Hoy et al., 2011; Lee & Lape, 2020; Roston, et al., 2008). Occupational therapists should feel confident that their contributions in handwriting acquisition are efficacious for improving handwriting and handwriting related outcomes. The results also suggests that the

manner of occupational therapy involvement, or the delivery approaches occupational therapists employ, are not equally supported. Therefore, it is important to identify which of the occupational therapy delivery approaches provides the greatest and most feasible benefits to students learning to write.

Clinical Implications: Interpreting the Results

The Traditional Approach. The Traditional approach aligns well with the current common practice that designates teachers as the initial handwriting instructors with the responsibility of identifying students with handwriting difficulties. Results from this review indicate that there is strong evidence that students with identified handwriting difficulties who participate in occupational therapy services, exhibit improved handwriting outcomes including legibility, (Case-Smith, 2002; Denton et al., 2006; Weintraub et al., 2009) graphomotor and fine-motor skills (Ratzon et al., 2007), and far point copying (Chang & Yu, 2017), compared with students who only participate in conventional teacher-led handwriting instruction.

While the Traditional approach to handwriting intervention shows a positive impact on handwriting acquisition, there are notable disadvantages. First, removing students from the classroom to participate in occupational therapy services reduces the time in the classroom to participate in the intended academic schedule with the teacher and other students (Case-Smith, Weaver, & Holland, 2014). Additionally, pulling students out of the classroom is contrary to current trends in best practices that promote service delivery in the natural environment, in this case, the general education classroom (Bazyk & Cahill, 2014; Seruya & Garinkel, 2018). According to Watt et al., (2021), occupational therapy is “most effective” when integrated in the natural setting; otherwise, they warn, “skills learned outside the natural contexts may not generalize” (Watt et al., 2021, p. 2). Moreover, in practice the traditional approach may lack

enduring feasibility. Research indicates that handwriting difficulty is reportedly the most common reason school-aged children are referred for occupational therapy services (Schneck & Amudson, 2010; Cramm & Egan, 2015). Moskowitz et al., (2017) found that up to 75% of occupational therapists' caseloads are handwriting related. Results from another study suggest that handwriting referrals dominate caseloads at a rate of 84% (Bolton and Platter; 2020). In practice, school-based occupational therapists are often overloaded with the numbers of referrals they receive (Asher, 2006). In a survey published in 2020, the majority of occupational therapists indicated that "the current number of students on their caseload was not reasonable and did not always allow them to manage all of their workload responsibilities" (Seruya & Garfinkel, 2020). By proactively incorporating occupational therapy services in the classroom during handwriting instruction, Donica et al., suggest, "students' difficulties with handwriting could be dealt with at the Tier 1 level and referral to occupational therapy may not be necessary" (Donica et al., 2012, p. 123). Granting occupational therapists the opportunity to contribute "to the effectiveness of the initial handwriting instruction" and be present to recommend and trial effective interventions with students if handwriting difficulties surface, provides a practical way to ameliorate excessive referrals (Asher, 2006, p. 469).

Teacher Implemented OT Curriculum. Only one study located for this review examined the efficacy of teachers implementing occupational therapy developed curriculum without further occupational therapy participation (Hunter & Potvin, 2019). This delivery approach can provide teachers in general education classrooms with developmentally appropriate curriculum that can be employed consistently across classrooms and grade levels. Previous research has found that implementing occupational therapy developed curriculum can improve handwriting legibility (Engel et al., 2018). The question that arises is whether teachers are able to use these curricula

effectively in the absence of further occupational therapy contributions. Although Hunter and Potvin (2019) did not find evidence to support this delivery approach, more studies are needed before concluding that this method is without merit. While the prevalence of this approach in practice may be relatively minor, one on-line survey of 505 North Carolinian elementary teachers found that at least 10% of respondents reported using an occupational therapy developed curriculum (Handwriting Without Tears) to teach handwriting (Donica et al., 2012). In order to ensure the value of this approach, future research should focus on the level of training each teacher receives prior to implementing the curriculum.

Consultation. Consultation prescribes more occupational therapy inclusion than when teachers implement occupational therapy developed curriculum. This approach allows all students to benefit from the expertise of both teachers and occupational therapists. All of the studies in this review that employed the Consultation approach found a significant improvement in handwriting outcomes from pretest to posttest. This is consistent with previous research that demonstrates the importance of occupational therapists supporting classroom teachers with the development and implementation of handwriting instruction for all students (Howe et al., 2013; Hutton, 2009; Randall, 2018). Moderate evidence for this approach is promising but would benefit from more level I studies. Also, future research is needed to determine the most effective and most feasible manner for occupational therapists to consult with teachers including how often occupational therapists are present in the classrooms during handwriting instruction.

Team-Teaching. Team-Teaching is an important development in school-based occupational therapy. The knowledge and skill set of the occupational therapist with handwriting interventions can “complement the skills of the teacher in writing, curriculum, and management of classroom behaviors to create a comprehensive program that meets the diverse needs” of the

students (Case-Smith et al., 2012). All of the studies in this review that apply the Team-Teaching delivery approach, found a statistically significant improvement in handwriting outcomes when compared with conventional teacher-led instruction. This mirrors previous research that indicates that integrating occupational therapy in the classroom improves handwriting and handwriting related outcomes (Bazyk et al., 2009; McCarroll & Fletcher, 2017; Ohl et al., 2013; Roston et al., 2008). Future research can strengthen the confidence of these findings with the addition of level I studies using random control trials.

OT Led. The OT Led approach to handwriting instruction emerges from the literature due in large part to the research design needed to complete the studies. Although this approach has not been described in the literature as currently practiced, this review found promising results. This delivery approach should not be viewed as revolutionary. It is in line with a national (United States) survey that found “teachers overwhelmingly believed that handwriting should be taught as a separate subject” (Graham et al., 2008, p. 63). One can view this approach as providing a specialist to instruct a specific skill in much the same way as an art teacher teaches art and a music teacher teaches music. The viability of this approach depends on its feasibility and efficacy compared with the other more established approaches. Additional research is warranted.

Clinical Implications: Summary

Due to insufficient evidence, it is not currently recommended that occupational therapy involvement in handwriting acquisition be limited to simply providing curriculum for classroom teachers to implement. While this approach provides consistent verbiage, guidelines, and activities for handwriting instruction, the findings from this review did not indicate that this approach produces significantly greater handwriting outcomes for students than conventional

teacher-generated instruction. Furthermore, although strong evidence supports the efficacy of an OT Led approach in kindergarten and first grade compared with conventional teacher-led instruction, without any confirmation of its feasibility in practice, it also cannot currently be recommended.

Strong evidence supports the Traditional approach for handwriting remediation compared with conventional teacher-led instruction. Although this approach can be recommended, it has an inherent limitation because it only considers students with identified handwriting difficulties and pulls students out of the classroom for service delivery. As noted, this overlooks the benefits that occupational therapists can provide to the entire student population in the natural environment. Offering the most promise then are the Consultation and Team-Teaching approaches as they encourage and often necessitate the direct access of the occupational therapists to all students in the classroom from the onset of handwriting instruction. Inserting occupational therapists in such a way has multiple benefits. First, this allows for consistency with handwriting instruction that the classroom teacher can carry over throughout the school day. Second, it allows students to benefit from the combination of the distinct skillsets provided by both the occupational therapists and the classroom teachers. Third, having occupational therapists present in the classroom for handwriting instruction allows for immediate recognition of blooming handwriting difficulties that can be swiftly addressed. If student difficulties can be ameliorated in the classroom, then “only students who have genuine deficits ... would be referred for remediation.” (Asher, 2006, p. 469). Finally, as noted by Pfeiffer, Rai et al. (2015), the financial cost of occupational therapy collaboration is significantly less than individual occupational therapy intervention which can save districts money.

The findings from this review also suggest that students in different grade levels may benefit varying degrees from the different delivery approaches. The evidence suggests that kindergarten students that are initially learning the fundamentals of letter construction may benefit most from the occupational therapy involvement characteristic of the Team-Teaching and Consultation delivery approaches. Findings also suggest that in later grades, a reactive traditional approach is beneficial if students continue to exhibit handwriting challenges.

Limitations and Directions for Future Research

This systematic review establishes strong evidence for occupational therapy involvement in handwriting acquisition compared with conventional teacher-led classroom instruction. However, confidence in these findings can be improved further in multiple ways. Notably, the majority (18 out of 24) of the research articles utilized in this review are level II cohort studies. More Level I studies with randomized group assignments and blinding for both scorers and administrators are needed. Next, shared limitations of the studies included in this review are apparent. First, many of the studies were limited by small sample sizes. Also, many studies included in this review did not specify details involved with conventional teacher-led instruction of handwriting. Information regarding content, frequency, and feedback provided is relevant and can point to fundamental reasons why occupational therapy intervention was significantly more effective in multiple aspects of handwriting.

Furthermore, due to the curriculum constraints, only one reviewer was used to complete this systematic review. Having multiple reviewers would add another layer of consensus to the article inclusion and appraisal processes.

Finally, although this review demonstrates strong evidence that occupational therapy involvement in handwriting acquisition improves handwriting outcomes when compared with

conventional teacher-led instruction, more research is needed to improve confidence in identifying which delivery approach provides the most efficacy and feasibility in practice. There were multiple variables used across the studies for this review, including various curriculum, frequency and duration of handwriting intervention, and outcomes measured. To strengthen confidence further, future research should employ consistent variables. Additionally, future research should directly compare the different delivery approaches to better understand the efficacy of each.

Implications for Occupational Therapy Practice

The results of this systematic review suggest the following considerations for occupational therapy:

- Occupational therapy involvement in handwriting acquisition skills, significantly improves handwriting outcomes such as handwriting readiness, handwriting speed, handwriting legibility, fine motor coordination, and far point copying for students learning to write compared with conventional teacher-led instruction.
- The Traditional reactive delivery approach for occupational therapy handwriting intervention significantly improves handwriting outcomes for students that have been identified as having a handwriting difficulty compared with conventional teacher-led handwriting instruction.
- When occupational therapists are involved with handwriting acquisition in the classroom, they are able to identify individual student needs and provide immediate feedback in terms of specific interventions or support.
- Combining the complimentary skillsets of occupational therapists and classroom teachers during initial handwriting instruction provides a comprehensive platform that

significantly improves handwriting outcomes when compared with conventional teacher-led handwriting instruction.

Conclusion

The impact of occupational therapy involvement on handwriting instruction was overwhelmingly found to be beneficial for improving handwriting outcomes when compared with conventional teacher-led classroom instruction. In large measure, available evidence suggests that improvements in areas of handwriting readiness, handwriting speed, handwriting legibility, fine motor coordination, and far point copying were significantly greater than improvements gained from conventional teacher-led instruction. The data that emerged in this review indicates that there are five different delivery approaches for occupational therapist to participate in handwriting instruction. The most promising approaches, Consultation and Team Teaching, encourage or necessitate an occupational therapy presence in the classroom as initial handwriting instruction occurs. However, future research is needed to directly compare each of the delivery approaches in order to identify which approach can be most effectively and feasibly incorporated into the handwriting instruction process.

Table 1*Risk of Bias Table*

Citation	Sample Bias		Performance Bias	Direction Bias		Attrition	Reporting Bias
	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding Outcome Assessment: Self-Reported Outcomes	Blinding of Outcome Assessment: Objective Outcomes	Incomplete Outcome Data	Selective Reporting
Case-Smith (2002) doi.org/10.5014/ajot.56.1.17	NA	NA	NA	NA	NA	+	+
Case-Smith, Holland, & White (2014) doi.org/10.5014/ajot.2018.027110	NA	NA	?	NA	+	+	+
Case-Smith, Weaver, & Holland (2014) https://doi: 10.5014/ajot.2014.011585	NA	NA	?	NA	+	+	+
Chandler, Mulder, & Nall (2014) https://doi.org/10.1080/19411243.2014.930618	NA	NA	NA	?	?	+	NA
Chang & Yu (2017)	+	NA	NA	?	?	-	-
Denton, Cope, & Moser (2006) https://doi: 10.5014/ajot.60.1.16	+	NA	NA	NA	+	+	+
Donica (2015)	NA	-	-	NA	-	?	+

http://dx.doi.org/10.5014/ajot.2015.018366							
Donica, Goins, & Wagner (2013)	NA	-	-	NA	-	+	+
https://doi.org/10.1080/19411243.2013.810938							
Donica, McCraw, Hudson & Cason (2013)	NA	NA	NA	NA	+	?	+
Hape, Flood, McArthur, Sidara, Stephens, & Welsh (2014)	NA	NA	NA	NA	+	+	+
https://doi:10.1080/19411243.2014.975071							
Hunter & Potvin (2019)	NA	NA	NA	+	+	?	+
https://doi.org/10.1080/19411243.2019.1647813							
Jordon, Michaud & Kaiser (2016)	NA	NA	NA	+	+	?	+
https://doi.org/10.1080/19411243.2016.1178034							
Kaiser, Alberet, & Doudin (2011)	NA	?	?	NA	?	+	+
doi:10.2466/11.25.pms.112.2.610-618							
Lust & Donica (2011)	NA	-	-	NA	-	+	+
DOI: 10.5014/ajot.2011.000612							
Peterson & Nelson (2003)	+	+	NA	NA	+	+	+
doi:10.5014/ajot.57.2.152							
Pfeiffer, Rai, Murry, & Brusilovskiy (2015)	NA	?	NA	NA	?	+	+

doi: 10.1177/1539449215573004							
Pfeiffer, Moskowitz, Paoletti, Brusilovskiy, Zylstra, & Murray (2015)	NA	?	NA	NA	+	+	+
http://dx.doi.org/10.5014/ajot.2015.015826							
Ratzon, Efraim, & Bart (2007)	+	NA	NA	NA	?	+	+
doi: 10.5014/ajot.61.4.399							
Roberts, Derkach-Ferguson, Siever, & Rose (2014)	NA	NA	NA	+	+	+	+
doi: 10.1177/0008417414527065							
Schneck, Shasby, Myers, & Depoy Smith (2012)	NA	NA	NA	NA	+	+	+
doi: 10.1080/19411243.2012.675759							
Taras, Brennan, Gilbert, & Eck Reed (2011)	NA	-	?	NA	?	?	+
doi.org/10.1080/19411243.2011.629554							
Weintraub, Yinon, Bar-Effat Hirsch, Parush, (2009)	+	+	?	NA	+	+	+
doi: 10.3928/15394492-20090611-05							
Zwicker & Hadwin (2009)	+	NA	NA	NA	+	+	+

Zylstra & Pfeiffer (2016)	NA	NA	NA	NA	NA	?	+
http://dx.doi.org/10.5014/ajot.2016.018820							

Note. Categories for risk of bias: + = low risk of bias; ? = unclear risk of bias; - = high risk of bias. NA = not applicable. Risk-of-bias table format adapted from “Assessing risk of bias in included studies,” by J. P. T. Higgins, D. G. Altman, and J. A. C. Sterne, in *Cochrane Handbook for Systematic Reviews of Interventions* (Version 5.1.0), by J. P. T. Higgins and S. Green (Eds.), March 2011. Retrieved from <http://www.cochrane-handbook.org>. Copyright 2011 by The Cochrane Collaboration.

Table 2*Evidence Table*

Author/year/country	Level of evidence/study design/inclusion criteria	Intervention and control groups	Intervention length and delivery approach	Outcome measures	Key results for present review
Case-Smith (2002) USA	<p>Level II</p> <p><i>Study Design:</i> 2 groups, nonrandomized, Pretest/Posttest</p> <p><i>Original N</i> = 44</p> <p><i>Inclusion Criteria:</i> 2nd, 3rd, and 4th grade students identified as having poor handwriting</p>	<p><i>Intervention:</i> Traditional pull-out OT services: Individualized interventions based on the student's need. Handwriting practice using eclectic approaches (combining published curricula and programs) implemented 77% of sessions. OTs reported communication with teachers and parents.</p> <p><i>Developers:</i> OTs</p> <p><i>Providers:</i> OTs</p> <p>n = 29</p> <hr/> <p><i>Control:</i> No OT services</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 9</p>	<p><i>Length:</i> 30 min/wk for 7 months (mean 16.4 sessions, 528 min)</p> <p><i>Delivery approach:</i> Traditional</p>	<p>3 subtests of DTVP (position in space, figure ground perception, and copying)</p> <p>2 subtests of BOTMP (visual-motor control and upper-limb speed and dexterity)</p> <p>Nine-hole peg test</p> <p>ETCH</p> <p>SFA</p>	<p><i>Overall results:</i> Students who received occupational therapy services exhibited improvement in letter legibility but not speed.</p> <p><i>Individual results related to PICO question:</i></p> <p>Intervention group made significantly more progress in handwriting legibility (ETCH) than control ($p = .054$)</p> <p>Speed increase (ETCH) was smaller for intervention group than control, though not statistically significant ($p = .838$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition</p>

					significantly improves handwriting legibility compared conventional teacher-led instruction.
Case-Smith, Weaver, & Holland (2014) USA	Level II <i>Study Design:</i> Nonrandomized two group comparison <i>Original N = 139</i> <i>Inclusion Criteria:</i> 1 st grade classroom (x8)	<i>Intervention:</i> Write Start program – Classroom-embedded coaching teams (1 st grade teacher, Intervention Specialist, and OT). Provides instruction with individualized supports to prevent handwriting problems and promote writing fluency in 1 st grade students of all ability levels. Uses team teaching and station training with active student participation. Teacher and OT meet weekly to review student progress and plan weekly sessions <i>Developer:</i> OT <i>Providers:</i> Co-teaching Teams (1 st grade teacher, Intervention Specialist, and OT) n = 77 <hr/> <i>Control:</i> Teacher led handwriting instruction 3-4 days/wk, spending 15-20 minutes to introduce or review 1-2 letters in the morning. Students completed short writing assignments	<i>Length:</i> 45 mins, 2x/wk for 12 wks <i>Delivery approach:</i> Team-Teaching	ETCH-M WJ -III	<i>Overall results:</i> Students participating in the Write Start program improved more in handwriting legibility and speed than students receiving standard instruction. <i>Individual results related to PICO question:</i> Compared with students in standard instruction, students in the Write Start program improved significantly more in lowercase legibility (ETCH-M) ($p < .001$) Both groups made significant improvements in speed (ETCH-M) ($p < .001$) Write Start students increased their speed by 127 s compared with 87 s for the standard instruction students ($p = .025$) Difference in fluency 6 mo follow-up for intervention

		<p>on most days. Workbooks and visual models were used.</p> <p><i>Developer:</i> district’s writing curriculum</p> <p><i>Provider:</i> classroom teachers</p> <p>n = 58</p>			<p>group was statistically significant (WJIII) ($p = .005$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting legibility, speed, and fluency at 6 mo follow-up compared with conventional teacher-led instruction.</p>
<p>Case-Smith, Holland, & White (2014)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Nonrandomized comparison pretest, post tests</p> <p><i>Original N = 67</i></p> <p><i>Inclusion Criteria:</i> 1st grade students</p>	<p><i>Intervention:</i> Write Start program – embedded Co-taught handwriting class for 1st grade students. Links handwriting instruction to authentic writing and emphasizes practice. Includes weekly meetings with teachers to discuss students’ progress and possible supports needed.</p> <p><i>Developer:</i> OT</p> <p><i>Providers:</i> Co-teaching Teams (two teachers and an occupational therapist)</p> <p>n = 37</p> <hr/>	<p><i>Length:</i> 45min, 2x/wk for 12 wks</p> <p><i>Delivery approach:</i> Team-Teaching</p>	<p>ETCH – M</p> <p>WJ- III</p>	<p><i>Overall results:</i> Students in the Write Start program improved significantly more in legibility and fluency than students receiving standard classroom instruction.</p> <p><i>Individual results related to PICO question:</i> The intervention group made more progress than students in the standard instruction group in lower case alphabet legibility (ETCH) ($p = .02$) and writing fluency (WJIII) ($p = .05$) and wrote twice as many sentences as students in the comparison group, suggesting a meaningful difference in fluency.</p>

		<p><i>Control:</i> Teacher instruction – 20 minutes, 4 days per week, to introduce or review 1-2 letters. Letters were reinforced throughout the day as students were assigned short writing assignments almost daily.</p> <p><i>Developer:</i> not specifically defined</p> <p><i>Provider:</i> classroom teacher</p> <p>n = 30</p>			<p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting legibility and fluency more than conventional teacher-led instruction.</p>
<p>Chandler, Mulder, & Nall (2014)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Quasi-experimental group comparison pretest/posttest</p> <p><i>Original N=</i> 66</p> <p><i>Inclusion Criteria:</i> Montessori preschool classroom (x2) typically developing</p>	<p><i>Intervention:</i> Video-based modeling using the Alphabet Beats DVD: 5 min letter chapters using Montessori movable alphabet; features teacher modeling strokes; Offered as an activity choice/internal motivation</p> <p>Teachers and aides operated tech but did not offer feedback regarding performance, and did not start, stop, or slow the video during viewing.</p> <p>Researchers visited classrooms twice a month to review procedures</p> <p>Intervention group also worked on the Montessori phonics program</p> <p><i>Developers:</i> OT and parent colleague</p>	<p><i>Length:</i> 16 weeks</p> <p><i>Delivery approach:</i> Consultation</p>	<p>Number of viewings per student</p> <p>MHA</p>	<p><i>Overall results:</i> Legibility improved in both classrooms, but students who had access to the video-based modeling showed greater improvement in letter legibility.</p> <p><i>Individual results related to PICO question:</i> For intervention group, legibility (MHA) improved significantly more than control classroom ($p < .01$)</p> <p>Students who viewed the DVDs produced more legible letters from copy, independent of viewing frequency.</p>

		<p><i>Provider:</i> Teacher and aids operated technology and encouraged students to practice after watching video</p> <p>n = 35</p> <hr/> <p><i>Control:</i> Montessori method/ Phonics program – emphasizes student self-discovery and responsibility. Multisensory, bottom-up approach used for handwriting. Students learn to identify letter shapes with letter sounds, rather than letter name. Students trace letter shapes with a finger while verbalizing the sound.</p> <p><i>Developer:</i> Maria Montessori (physician and educator)</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 31</p>			<p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting legibility more than teacher-led Montessori instruction.</p>
Chang & Yu (2017) Taiwan	<p>Level I</p> <p><i>Study Design:</i> Random control trial</p> <p><i>Original N</i> = 28</p> <p><i>Inclusion Criteria:</i> 1st and 2nd graders with identified</p>	<p><i>Intervention:</i> Sensorimotor – training on visual-perceptual and haptic-perceptual activities (no other handwriting instruction provided through intervention). Conducted in groups. Intervention group did also participate in classroom handwriting instruction</p> <p><i>Developer:</i> OT</p>	<p><i>Length:</i> 45 min, 2x/wk for 6 wks</p> <p><i>Delivery approach:</i> Traditional</p>	<p>TVPS-3</p> <p>TPT</p> <p>BCBL</p>	<p><i>Overall results:</i> Students participating in the intervention showed significant improvement with visual skills and far-point copying compared with teacher-led handwriting instruction.</p>

	dysgraphic characteristics referred by teachers	<p><i>Provider:</i> OT trained providers</p> <p>n = 14</p> <hr/> <p><i>Control:</i> teacher-led classroom instruction</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 14</p>			<p><i>Individual results related to PICO question:</i> Intervention group showed significant improvement on the TVPS-3 (visual skills) ($p < .048$), on the BCBL (far-point copying) ($p = .042$), but not the TPT (tactical performance) ($p = .861$).</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition using sensorimotor training, improves the handwriting outcomes addressed in the intervention, compared with teacher-led instruction.</p>
Denton, Cope, & Moser (2006) USA	<p>Level I</p> <p><i>Study Design:</i> three group pretest and posttest - random assignment</p> <p><i>Original N</i> = 38</p> <p><i>Inclusion Criteria:</i> 1st, 2nd, 3rd and 4th grade students with handwriting</p>	<p><i>Intervention 1:</i> Sensorimotor group (SM): Visual perception, visual-motor integration, proprioception/kinesthesia, in-hand manipulation. In school – separate from classroom instruction</p> <p><i>Developers:</i> A focus group of experienced school-based therapists provided advice.</p>	<p><i>Length:</i> 40 min, 4x/wk for 5 wks</p> <p><i>Delivery approach:</i> Traditional</p>	<p>THS</p> <p>DTVP – 2</p> <p>TMP</p> <p>IHM</p>	<p><i>Overall results:</i> Students using therapeutic practice as a handwriting intervention improved handwriting performance more than students using a sensorimotor-based intervention or standard classroom handwriting instruction.</p> <p><i>Individual results related to PICO question:</i></p>

	<p>dysfunction but no identified exceptional education need</p>	<p><i>Providers:</i> Experienced school-based therapists (4 OTs and 1 PT) trained in intervention</p> <p>n = 14</p> <hr/> <p><i>Intervention 2:</i> Therapeutic practice (TP): Practice books based on motor learning strategies (work sheets, real-life writing, writing for fun). In school – separate from classroom instruction</p> <p><i>Developer:</i> Not specifically defined.</p> <p><i>Providers:</i> Experienced school-based therapists (4 OTs and 1 PT) trained in intervention</p> <p>n = 15</p> <hr/> <p><i>Control:</i> Standard classroom instruction - not specifically defined</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 9</p>			<p>Compared with sensorimotor group, therapeutic practice group showed statistically significant improvement with handwriting performance (THS) ($p = .001$).</p> <p>SM group – improvement in visual perception (DTVP-2) ($p = .02$ – compared to control; $p = .362$ -compared to TP group) but declined in handwriting performance</p> <p>Control group – no statistically significant changes</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting outcomes compared with teacher-led instruction.</p>
Donica (2015)	Level II	<p><i>Intervention:</i> Handwriting Without Tears (HWT). Forming letters with</p>	<p><i>Length:</i> 15 min/day, 5 days/wk</p>	THS -R	<p><i>Overall results:</i> Students participating in the HWT</p>

<p>USA</p>	<p><i>Study Design:</i> Static group comparison</p> <p><i>Overall N = 59</i></p> <p><i>Inclusion Criteria:</i> Kindergarten</p>	<p>multisensory manipulatives, handwriting song, or workbook writing. OT consultation 1x/wk.</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> trained teacher with OT consultation</p> <p>n = 40</p> <hr/> <p><i>Control:</i> teacher instruction of D’Nealian style writing</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 19</p>	<p><i>Delivery approach:</i> Consultation</p>		<p>intervention outperformed students in the control (teacher led D’Nealian) group.</p> <p><i>Individual results related to PICO question:</i> Intervention group scored significantly higher than the control group on all THS – R subtests and on overall score ($p < .05$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting outcomes more than conventional teacher-led instruction.</p>
<p>Donica, McCraw, Hudson & Cason (2013)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Static group comparison Not randomized</p> <p><i>Original N = 53</i></p> <p><i>Inclusion Criteria:</i> Kindergarten</p>	<p><i>Intervention:</i> HWT – gross motor activity with a handwriting related song and learning activity (letter formations with multisensory manipulatives or workbook writing).</p> <p>One time per week an OT and/or two OT grad students were present in the room during the 15- minute handwriting instruction time. This presence allowed the occupational therapy personnel to answer questions regarding the</p>	<p><i>Length:</i> Approx. 15 min daily</p> <p><i>Delivery approach:</i> Consultation</p>	<p>THS -R</p>	<p><i>Overall results:</i> Students participating in the HWT intervention outperformed students in the control group (teacher-led D’Nealian).</p> <p><i>Individual results related to PICO question:</i> Students receiving the intervention had significantly higher scores on the THS-R for handwriting legibility than those who used only the D’Nealian style with</p>

		<p>implementation of the curriculum as well as provide occasional assistance to struggling writers.</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> trained teacher</p> <p>n = 28</p> <p><i>Control:</i> Teacher-led instruction of the D’Nealian style handwriting using worksheets.</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 25</p>			<p>no formal handwriting program ($p = .002$).</p> <p>The intervention group outscored the control on all subtests and total raw scores with 5 (uppercase and lowercase letters from memory, writing uppercase letters from dictation, copying selected upper and lowercase letters from dictation), of the 10 subtests reflecting significant differences when adjusting for age and gender ($p < .05$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition, through consultation, improves handwriting outcomes compared with conventional teacher-led instruction.</p>
<p>Donica, Goins, & Wagner (2013)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Quasi-experimental with a non-equivalent control group – pretest,</p>	<p><i>Invention:</i> Classroom A: The Fine Motor and Early Writing Pre-K Curriculum (FMEW): address fine motor skills, perceptual motor skills, prewriting skills, and number and letter formation. Bottom-up approach is emphasized.</p>	<p><i>Length:</i> 10 -15 min, 2x/wk for 16 wks</p> <p><i>Delivery approach:</i> OT led</p>	<p>SHS</p>	<p><i>Overall results:</i> Students participating in handwriting readiness programs and in Head Start programs showed improvements in prewriting skills, but the improvements were not statistically</p>

	<p>posttest, nonrandomized sample selection</p> <p><i>Original N = 58</i></p> <p><i>Inclusion Criteria:</i> preexisting Head Start Classroom (x3)</p>	<p>Intervention completed in classroom but by research assistants alone – no teacher involvement</p> <p>Intervention groups also participated in Head Start programing</p> <p><i>Developer:</i> OT</p> <p><i>Providers:</i> Trained graduate research assistants (Occupational therapy students)</p> <p>n = 18</p> <hr/> <p><i>Intervention:</i> Classroom B: Handwriting Without Tears – Get Set for School (HWT-GSS); Gross motor warm-up, multi-sensory approach to teach body awareness and foster fine motor development, activities to practice in-hand manipulation and positioning</p> <p>Intervention completed in classroom but by research assistants alone – no teacher involvement</p> <p>Intervention groups also participated in Head Start programing</p>			<p>significant when compared with students receiving only Head Start programing.</p> <p><i>Individual results related to PICO question:</i> Students in all three classrooms Showed improvements in handwriting-related skills, but changes did not reach significance between students in all classrooms ($p = .837$).</p> <p><i>*Key result related to PICO question:</i> Occupational Therapy involvement in handwriting acquisition did not significantly improve acquisition skills compared with conventional teacher- led instruction.</p>
--	---	---	--	--	--

		<p><i>Developer:</i> OT</p> <p><i>Provider:</i> Trained graduate research assistants (Occupational therapy students)</p> <p>n = 20</p> <hr/> <p><i>Control:</i> Classroom C - Head Start -</p> <p><i>Developer:</i> Federally produced. More specific information regarding developers were not discussed.</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 20</p>			
<p>Hape, Flood, McArthur, Sidara, Stephens, Welsh (2014)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> pretest/posttest non-randomized control</p> <p><i>Original N = 43</i></p> <p><i>Inclusion Criteria:</i> 1st grade (2 classrooms)</p>	<p><i>Intervention:</i> HWT – multisensory approach to handwriting.</p> <p>OT and OT grad students went to classroom to review letters and writing concepts in small groups of five to six students.</p> <p>All students in the intervention also participated in Writer’s Workshop</p> <p>OT also provided support to classroom teacher through</p>	<p><i>Length:</i> Intervention: 1 - 3x/wk, plus OT support, 20 min 1x/wk, 20 sessions</p> <p><i>Delivery approach:</i> Consultation</p>	<p>The Print Tool (assessment developed with contributions from Jan Olsen who also is the main contributor to HWT)</p>	<p><i>Overall results:</i> Students participating in the combination of the Writer’s Workshop and HWT curriculum showed more (but not statistically significant) improvement in the handwriting outcome measure than students that only participated in the Writing Workshop.</p> <p><i>Individual results related to PICO question:</i></p>

		<p>orientation and email throughout the year</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> Teacher, reinforced by OT grad students in small groups throughout the year</p> <p>n = 21</p> <hr/> <p><i>Control:</i> Writer’s Workshop – emphasizes the development of sentence writing and focuses on content rather than letter formation. Students are given the opportunity to practice writing.</p> <p>4x/wk throughout school year (standard curriculum without OT support)</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 22</p>			<p>Both groups showed improved scores on the Print Tool. Intervention group showed higher outcome scores, but these were not statistically significant ($p > .05$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition did not significantly improve handwriting outcomes compared with conventional teacher-led instruction.</p>
<p>Hunter & Potvin (2019)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> two-group time series</p> <p><i>Original N = 51</i></p>	<p><i>Intervention:</i> SMHP – utilizes explicit teaching instructions and practice, self-assessment, feedback, and motivators.</p> <p><i>Developer:</i> OT</p>	<p><i>Length:</i> 10 – 15 min/ 5x/wk</p> <p><i>Delivery approach:</i> Teacher</p>	<p>ETCH – M</p> <p>VMI</p> <p>Interview</p>	<p><i>Overall results:</i> Students who received SMHP instruction and students who received conventional classroom instruction made statistically significant gains in</p>

	<p><i>Inclusion Criteria:</i> Kindergarteners from gen ed classes in a public school</p>	<p>Provider: teachers (using teaching manuals) No OT involvement (aside from utilizing an OT developed program)</p> <p>n = 35 (2 classes)</p> <hr/> <p>Control: teacher led – visual demo, verbal feedback, practice time, tracing and copying</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> classroom teacher</p> <p>n = 16</p>	<p>Implemented OT Curriculum</p>		<p>handwriting legibility. The degree of improvement between groups was not statistically significant gains.</p> <p><i>Individual results related to PICO question:</i> Both groups improved significantly in terms of lowercase and uppercase legibility between the start and the end of the school year ($p < .0001$)</p> <p>The degree of improvement between the two groups was not statistically significant ($p = .39$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition did not significantly improve handwriting outcomes compared with conventional teacher-led instruction.</p>
<p>Jordan, Michaud, & Kasier (2016)</p> <p>Switzerland</p>	<p>Level II</p> <p><i>Study Design:</i> Quasi-experimental pretest/posttest</p>	<p><i>Intervention:</i> LetterSchool: uses animated models to teach letter formation. Combines fine motor activities, animated models, exercises on a tablet, and paper-pencil practice.</p>	<p><i>Length:</i> 10 min, 3x/wk, and 45 min, 1x/wk for 10 wks</p> <p><i>Delivery approach:</i> Consultation</p>	<p>BHK</p>	<p><i>Overall results:</i> Students participating in the LetterSchool curriculum made significant gains in letter legibility compared with students participating in usual</p>

	<p>control group - nonrandomized</p> <p><i>Original N = 20</i></p> <p><i>Inclusion Criteria:</i> 1st grade</p>	<p><i>Developer:</i> OT student</p> <p><i>Provider:</i> teacher with OT student providing support 1x/wk for 45 min</p> <p>Close collaboration through email (OTs not school-based in Switzerland at time of publication)</p> <p>n = 16</p> <hr/> <p><i>Control:</i> Classroom instruction – not specifically defined</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 14</p>			<p>classroom handwriting instruction.</p> <p><i>Individual results related to PICO question:</i> Posttest scores were significantly better in the experimental group than in the control group ($p < .01$)</p> <p>No significant difference was found in the speed ($p < .69$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improved handwriting legibility more than conventional teacher-led instruction.</p>
<p>Kaiser, Alberet, & Doudin (2011)</p> <p>Switzerland</p>	<p>Level II</p> <p><i>Study Design:</i> two-group posttest only, nonrandomized groups</p> <p><i>Original N = 42</i></p>	<p><i>Intervention:</i> Explicit Handwriting program (cursive is taught before manuscript): Develop digital dexterity; discuss meaning; Learning and practicing; metacognitive tasks; teach 2-3 letters/session</p> <p>Additional handwriting sessions completed during school but separate from classroom. No description of OT/teacher collaboration.</p>	<p><i>Length:</i> 45 min, 2x/wk for 6 wks</p> <p><i>Delivery approach:</i> OT Led</p>	<p>BHK (French version)</p>	<p><i>Overall results:</i> Students participating in the explicit program showed better legibility and speed than students who participated in standard classroom instruction.</p> <p><i>Individual results related to PICO question:</i> Intervention group performed significantly better on speed and quality</p>

	<p><i>Inclusion Criteria:</i> Grade 1 (begins after 2 years of K)</p>	<p>Authors do not state if intervention group also participated in classroom handwriting instruction.</p> <p><i>Developer:</i> OT designed from evidence-based research</p> <p><i>Provider:</i> OT (Kaiser) and 2 OT students</p> <p>n = 23</p> <hr/> <p><i>Control:</i> Classroom instruction – 40 min, 1x/wk. Based on implicit learning - involves practicing 2-3 letters in a notebook. Students copy a letter several times and then copy words containing the letters.</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> classroom teacher</p> <p>n = 19</p>			<p>than the control group ($p < .01$).</p> <p>The handwriting of the experimental group contained significantly fewer ambiguous letters ($p < .05$), fewer corrections of letter forms ($p > .05$), and irregularities in joining strokes ($p < .01$) and a better arrangement of letters ($p < .05$) than the control group's handwriting.</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improved legibility and speed of handwriting compared with conventional teacher-led instruction.</p>
<p>Lust & Donica (2011) USA</p>	<p>Level II</p> <p><i>Study Design:</i> two-group, nonrandomized control trial with pretest/posttest</p>	<p><i>Intervention:</i> Handwriting Without Tears – Get Set for School (HWT-GSS) only capital letters: Gross motor warm-up, multi-sensory approach to teach body awareness and foster fine motor development, activities to practice in-hand manipulation and positioning</p>	<p><i>Length:</i> 20 min, 3x/wk for 47 sessions</p> <p><i>Delivery approach:</i> Team-Teaching</p>	<p>LAP</p> <p>BOT – 2</p> <p>Check Readiness</p>	<p><i>Overall results:</i> Students participating in HWT-GSS and Head Start programing made significant improvements in prewriting, kindergarten readiness, and fine-motor skills compared to</p>

	<p><i>Original N = 40</i></p> <p><i>Inclusion Criteria:</i> Head Start 4-5 yr-olds from low socio-economic status families</p>	<p>In addition to Head Start</p> <p>OTs on site and actively engaged in all aspects of the intervention and assessment process</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> OT grad students, OT, and trained Head Start Teacher</p> <p>n = 17</p> <hr/> <p><i>Control:</i> Head Start – not specifically defined</p> <p><i>Developer:</i> Federal program – not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 15</p>		<p>students only participating in the Head Start program.</p> <p><i>Individual results related to PICO question:</i> Invention group made significant improvements compared with the control group in prewriting, kindergarten readiness, and fine motor skills. Both groups made significant improvements between pretesting and post testing in prewriting, first name writing, and school readiness.</p> <p>LAP – $p = .0058$</p> <p>Check Readiness – $p = .022$</p> <p>BOT -2 – $p = .017$</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improved handwriting related outcomes compared with conventional teacher-led instruction.</p>
--	--	--	--	--

<p>Peterson & Nelson (2003)</p> <p>USA</p>	<p>Level I</p> <p><i>Study design:</i> Pretest/posttest experimental design with randomly assigned intervention and control groups</p> <p><i>Original N = 62</i></p> <p><i>Inclusion criteria:</i> 1st grade students from economically depressed neighborhood (80% of school considered homeless)</p>	<p><i>Intervention:</i> Handwriting club - Included sensorimotor, motor planning, motor memory, self-monitoring, learning strategies for size, placement, and spacing</p> <p>Completed in school but separate from classroom instruction. Students participated in classroom instruction as well</p> <p>Teachers were not informed of the content of the interventions until after study concluded</p> <p>Individualized daily plan</p> <p>Practice of D’Nealian handwriting</p> <p><i>Developer:</i> OT</p> <p><i>Providers:</i> OT students trained by OT</p> <p>n = 30</p> <hr/> <p><i>Control:</i> "regular academic instruction" – not specifically defined</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p>	<p><i>Length:</i> 30 mins, 2x/wk for 10 weeks (20 total sessions)</p> <p><i>Delivery approach:</i> OT Led</p>	<p>MHT</p>	<p><i>Overall results:</i> Students participating in the handwriting club had significant improvements in handwriting legibility compared with regular academic instruction.</p> <p><i>Individual results related to PICO question:</i> Gain scores for handwriting in the occupational therapy intervention group were significantly greater than those in the control group. Legibility and form $p < .05$; space, line, and size $p < .01$.</p> <p>Speed was not a dependent variable in this study.</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting legibility compared with conventional teacher-led instruction</p>
--	---	--	---	------------	--

<p>Pfeiffer, Moskowitz, Paoletti, Brusilovskiy, Zylstra, & Murray (2015a)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> two group pretest – posttest, randomized classroom assignment in Mass, nonrandomized in NY</p> <p>Original N = 207</p> <p>Inclusion Criteria: Kindergarten, 1st, and 2nd grades</p>	<p>n = 29</p> <p><i>Intervention:</i> Size Matters Handwriting Program (SMHP)- Can be embedded in school curriculum. Focus on letter size over form; incorporates direct instruction, mnemonics, incentives, frequent visual cuing, parent involvement, self-critiquing, and self-monitoring</p> <p>Site managers – OTs with specialized training in SMHP - available several times a week to provide support and answer questions</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> teachers trained in SMHP</p> <p>n = 103</p> <hr/> <p><i>Control:</i> Usual classroom handwriting instruction – not specifically defined</p> <p><i>Developer:</i> not defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 104</p>	<p><i>Length:</i> 20 mins, 5x/wk for 8 wks</p> <p><i>Delivery approach:</i> Consultation</p>	<p>VMI</p> <p>THS- R</p> <p>MHA</p>	<p><i>Overall results:</i> Students participating in the SMHP demonstrated significant improvements in handwriting outcomes compared with students who completed usual classroom instruction</p> <p><i>Individual results related to PICO question:</i></p> <p>Intervention group demonstrated significant improvements on handwriting measures MHA: $p < .01$</p> <p>No significant difference in VMI score VMI: $p < .05$</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly handwriting outcomes compared with conventional teacher-led instruction.</p>
--	---	---	--	-------------------------------------	--

<p>Pfeiffer, Rai, Murray, & Brusilovskiy (2015b)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Two-group pretest – posttest design. (Mass) Randomized class assignment to either treatment of non-treatment control groups (multiple classrooms per grade</p> <p>(NY) not randomized – convenience assignment due to teacher availability</p> <p>Original N = 207</p> <p>Inclusion Criteria: Kindergarten, 1st and 2nd grade whole regular education classrooms</p>	<p><i>Intervention:</i> SMHP - Focus on letter size over form; incorporates direct instruction, mnemonics, incentives, frequent visual cuing, parent involvement, self-critiquing, and self-monitoring</p> <p>Site managers – OTs with specialized training in SMHP - available several times a week to provide support and answer questions</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> trained classroom teachers</p> <p>n = 103</p> <p><i>Control:</i> varied between schools and grades. Use of eclectic mix of styles used to teach letter formation. Letters taught in alphabetical sequence. Verbal cuing and modeling utilized. No noted consistency between classes or school.</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 104</p>	<p><i>Length:</i> 20 mins, 5x/wk for 8 wks</p> <p><i>Delivery approach:</i> Consultation</p>	<p>THS – R</p> <p>MHA</p>	<p><i>Overall results:</i> Students participating in SMHP demonstrated significant improvement in handwriting legibility compared with students participating in classroom handwriting instruction.</p> <p><i>Individual results related to PICO question:</i></p> <p>Intervention groups showed improvement in form ($p < .05$), alignment ($p < .01$), and size ($p < .01$), qualities that contribute to handwriting competence in elementary School students. The intervention groups, in both first and second grades, showed the most improvement in the size subsection of the MHA ($p < .0001$) in comparison with the control group</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting legibility</p>
---	--	---	--	---------------------------	--

					compared with conventional teacher-led instruction
Ratzon, Efraim, & Bart (2007) Israel	Level I <i>Study Design:</i> pretest/posttest with random group assignment <i>Original N = 59</i> <i>Inclusion Criteria:</i> 1 st grade students with low on VMI from low-income neighborhood with mix of Arab and Jewish population	<i>Intervention:</i> OT graphomotor handwriting kit: motor learning, multisensory, dexterity and visual motor proficiency, FMC activities, pencil and paper Groups of 2 students In school – completed in OT room separate from classroom <i>Developer:</i> OT <i>Providers:</i> 10 OT students with experienced pediatric OT supervision n = 24 <hr/> <i>Control:</i> Classroom instruction – not specifically defined <i>Developer:</i> not defined <i>Provider:</i> Classroom teachers n = 28	<i>Length:</i> 45 min, 1x/wk for 12 sessions <i>Delivery approach:</i> Traditional	DTVP – 2 BOTMP	<i>Overall results:</i> Students who participated in occupational therapy for handwriting intervention demonstrated significant improvements in the graphomotor and fine-motor tests compared with students participating in usual classroom instruction. <i>Individual results related to PICO question:</i> Intervention group made significant gains in graphomotor test and fine-motor test BOTMP: $p = .000$ DTVP-2: $p = .001$ <i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting related outcomes compared with conventional teacher-led instruction
Roberts, Derkach-Ferguson, Siever, & Rose (2014)	Level I	<i>Intervention:</i> HWT – multisensory approach to handwriting instruction. <i>Developer:</i> OT	<i>Length:</i> 20 min, 5x/wk (on avg) for 9 weeks	MHA COPM	<i>Overall results:</i> Students participating in HWT demonstrated significantly higher improvements in

<p>Canada</p>	<p><i>Study Design:</i> Quasi-experimental crossover design Randomly drawn schools</p> <p><i>Original N</i> = 149</p> <p><i>Inclusion Criteria:</i> 1st grade class (x 10)</p>	<p><i>Provider:</i> Trained Teachers</p> <p>Teacher instruction was supported by coaching, provided by the occupational therapist and the HWT manual</p> <p>n = 77</p> <hr/> <p><i>Control:</i> teacher designed instruction – teachers did not use HWT techniques or materials. Not further defined.</p> <p><i>Developer:</i> Classroom Teacher</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 72</p>	<p><i>Delivery approach:</i> Consultation</p>		<p>handwriting legibility compared with students who participated in classroom instruction.</p> <p><i>Individual results related to PICO question:</i> Intervention group had significant improvements in form (p = .012 test 1-2, p = .015 test 2-3), size (p = .013 test 2-3) alignment (p = .009 test 2-3), spacing (p = .039 test 1-2), and overall (p = .017 test 1-2, p = .001 test 2-3) compared with control.</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting outcomes compared with conventional teacher-led instruction.</p>
<p>Schneck, Shasby, Myers, & Depoy Smith (2012)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Quasi-experimental pretest/posttest control design</p> <p><i>Original N</i> = 177</p>	<p><i>Intervention:</i> HWT: developmentally and multi-sensory based; Uses visual, auditory, tactile, and kinesthetic modalities to teach handwriting; incorporates practice</p> <p>Bimonthly consultation provided examples of activities (fact sheets) to</p>	<p><i>Length:</i> 15- 20 min/day for entire 1st grade</p> <p><i>Delivery approach:</i> Consultation</p>	<p>MHA</p>	<p><i>Overall results:</i> Students participating in teacher developed and led handwriting instruction demonstrated significant improvement in handwriting</p>

	<p><i>Inclusion Criteria:</i> 1st grade (x8) General Education (GE) and Special Education Services (SE)</p>	<p>facilitate skill development for handwriting and were specific to the underlying components of handwriting.</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> Teachers and therapists trained to use HWT</p> <p>n = 81 (GE =67, SE = 14)</p> <hr/> <p><i>Control:</i> Handwriting instruction designed and utilized by classroom teacher – not further defined</p> <p><i>Developer:</i> Classroom teacher</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 66 (GE = 54, SE = 12)</p>			<p>compared to students who participated in HWT.</p> <p><i>Individual results related to PICO question:</i> Both intervention and control groups showed improvements in MHA test results. The control group scored significantly higher than the intervention group ($p < .0001$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition did not improve handwriting outcomes compared with conventional teacher-led instruction</p>
<p>Taras, Brennan, Gilbert, & Eck Reed (2011)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Cohort - pretest-posttest with matched comparison group</p> <p><i>Original N</i> = 382</p>	<p><i>Intervention:</i> Write Direction: Designed to promote hand and finger skills, kinesthetic awareness of letter formation, correct directionality, and visual-motor skills. Uses combination of top-down and bottom-up approaches. Developed for use in classrooms.</p>	<p><i>Length:</i> 30 min, 1x/wk for 14 wks</p> <p><i>Delivery approach:</i> OT Led</p>	<p>Writing samples</p>	<p><i>Overall results:</i> Students who participated in the Write Direction program demonstrated statistically greater improvement in handwriting outcomes compared with students</p>

	<p><i>Inclusion Criteria:</i> Kindergarten students</p>	<p><i>Developer:</i> OTs - based on strategies commonly used occupational therapists with students exhibiting difficulty with handwriting</p> <p><i>Provider:</i> OT</p> <p>n = 201</p> <hr/> <p><i>Control:</i> teacher instruction</p> <p><i>Developer:</i> not specifically defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 155</p>			<p>receiving teacher-led handwriting instruction.</p> <p><i>Individual results related to PICO question:</i> Write Direction intervention students showed statistically significant improvement in handwriting skills between the pretest and posttest on letter task as compared to children who did not receive the intervention ($p < .001$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting outcomes compared with conventional teacher-led instruction.</p>
<p>Weintraub, Yinon, Bar-Effat Hirsch, Parush, (2009)</p> <p>Israel</p>	<p>Level I</p> <p><i>Study Design:</i> three group, pretest/posttest experimental design with random assignment</p> <p>Original N = 55</p>	<p><i>Intervention 1:</i> OT services provided in child development center: Multisensory (postural control, bilateral coordination, stability, and fine motor ability) plus handwriting activities</p> <p>4-6 students in a group</p> <p><i>Developer:</i> not specifically defined</p>	<p><i>Length:</i> 1hr, 1x/wk for 8 weeks</p> <p><i>Delivery approach:</i> Traditional</p>	<p>BATH</p> <p>MAC</p> <p>DTVP – 2 6 subtests (not described)</p> <p>BOTMP – 2 subtests for balance and</p>	<p><i>Overall results:</i> Student participating in either the multisensory intervention group or the task-oriented group demonstrated significant gains in handwriting outcomes compared with students only receiving conventional</p>

	<p><i>Inclusion Criteria:</i> 2nd, 3rd, and 4th grade students, general education with identified handwriting difficulties (referred by teachers or physicians)</p>	<p><i>Providers:</i> 2 experienced OTs N = 13</p> <hr/> <p><i>Intervention 2:</i> OT services provided in child development center: Task-Oriented focused handwriting intervention: writing letters (grouped by common basic formations – 5-letter groups) words and sentences, use of mnemonics to teach letter formation.</p> <p>4-6 students in a group</p> <p><i>Developer:</i> not specifically defined</p> <p><i>Providers:</i> 2 experienced OTs n = 13</p> <hr/> <p><i>Control:</i> Handwriting instruction taught in school</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teachers n = 17</p>		<p>upper-limb coordination</p> <p>PEERAMID – subtests for visual recognition and visual retrieval</p> <p>HHE</p>	<p>teacher-led-handwriting instruction.</p> <p><i>Individual results related to PICO question:</i> Intervention groups showed statistically significant gains in handwriting (all handwriting measures except for speed, $p < .05$). The control group did not show significant gains.</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting outcomes compared with conventional teacher-led instruction.</p>
<p>Zwicker & Hadwin (2009) Canada</p>	<p>Level I <i>Study Design:</i> Random control trial</p>	<p><i>Intervention 1:</i> Cognitive focused handwriting intervention: 1. Alphabet warm-up 2. Modeling</p>	<p><i>Length:</i> 30 min, 1x/wk for 10 wks <i>Delivery approach:</i></p>	<p>ETCH VMI</p>	<p><i>Overall results:</i> No significant differences were noted between students participating in the cognitive</p>

	<p><i>Original N = 72</i></p> <p><i>Inclusion Criteria:</i> 1st and 2nd grade students referred to OT services for handwriting difficulties</p>	<ol style="list-style-type: none"> 3. Imitation 4. Discussion 5. Practice 6. Evaluation <p>Individual therapy, at school but separate from the classroom</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> Trained OT</p> <p>n = 24</p> <hr/> <p><i>Intervention 2:</i> Multisensory focused handwriting intervention:</p> <ol style="list-style-type: none"> 1. Name letter 2. Copy letter 3. Sky writing 4. Tray of sand 5. Bumpy glitter glue 6. Marker and worksheet 7. Copy on lined paper <p>Individual therapy, at school but separate from the classroom</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> Trained OT</p> <p>n = 24</p> <hr/> <p><i>Control:</i> handwriting instruction in school</p>	<p>Traditional</p>	<p>focused handwriting intervention and students participating in teacher-led instruction in terms of letter legibility</p> <p><i>Individual results related to PICO question:</i> No significant difference in improvement if handwriting legibility with or without intervention ($\eta^2 = .04$)</p> <p>Intensity of intervention and similarity of intervention was questioned</p> <p>Medium effect size for both cognitive and multisensory intervention groups compared to control.</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition did not significantly improve handwriting outcomes compared with conventional teacher-led instruction</p>
--	---	---	--------------------	--

		<p><i>Developer:</i> not specifically defined</p> <p><i>Provider:</i> Classroom teacher</p> <p>n = 24</p>			
<p>Zylstra & Pfeiffer (2016)</p> <p>USA</p>	<p>Level II</p> <p><i>Study Design:</i> Two-group, pre-test – posttest design</p> <p><i>Original N</i> = 35</p> <p><i>Inclusion Criteria:</i> at-risk Kindergarteners (students currently receiving IEP or Rtl support)</p>	<p><i>Intervention:</i> SMHP – using SMHP workbook, 2 letters taught each session. Support room teachers encouraged to incorporate SMHP principles throughout the day</p> <p>Completed in addition to std instruction</p> <p><i>Developer:</i> OT</p> <p><i>Provider:</i> OT with adult helpers (support classroom teacher, occupational therapy assistant, educational assistant) trained by OT</p> <p>n = 23</p> <hr/> <p><i>Control:</i> School-based handwriting instruction</p> <p><i>Developer:</i> Not specifically defined</p> <p><i>Provider:</i> Classroom teachers</p> <p>n = 12</p>	<p><i>Length:</i> 30 min, 2x/wk for 16 wks</p> <p><i>Delivery approach:</i> Team Teaching</p>	<p>THS-R</p> <p>North Dakota Title I Kindergarten Reading Standards Assessment</p>	<p><i>Overall results:</i> Students participating in the SMHP demonstrated significant improvement in handwriting legibility compared with students participating in usual teacher-led instruction.</p> <p><i>Individual results related to PICO question:</i> Intervention group demonstrated considerably greater gains in handwriting legibility than students who participated in their school’s standard handwriting instruction only ($p = .000$)</p> <p><i>*Key result related to PICO question:</i> Occupational therapy involvement in handwriting acquisition significantly improves handwriting legibility compared with conventional teacher-led instruction.</p>

BATH – Brief Assessment Tool for Handwriting (Lifshitz & Parush, 1993); BCBL – Battery of Chinese Basic Literacy (Hung, Chang, Chen, Chen, & Lee; The Elementary Reading and Writing Test (Hung et al., 2003); BHK - BHK Concise Assessment Scale for Children's Handwriting (Charles, Soppelsa, & Albert, 2003); BOTMP – The Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978); COPM (Canadian Occupational Performance Measure, Law, Baptiste, Carswell, McColl, Polatajko, Pollock, 1998); DTVP- 2 – Developmental Test of Visual Perception (Hammill, Pearson, & Voress, 1993); ETCH – Evaluation Tool of Children's Handwriting (Amundson, 1995); FMEW - Fine Motor and Early Handwriting Pre-K Curriculum; SHS - The Shore Handwriting Screening for Early Handwriting Development, (Shor, 2003); HHE – The Hebrew Handwriting Evaluation (Erez & Parush, 1999); HWT – Handwriting Without Tears (Olsen, 2003); IHM – In-Hand Manipulation (Pehoski, Henderson, & Tickle-Degnen 1997a, 1997b); Learning Accomplishment Profile, 3rd Edition (LAP-3; Hardin & Peisner-Feinberg, 2004); Loops and other Groups (Benbow, 1990); MAC – The Motor Accuracy Test (Ayres, 1989); PEERAMD – The Pediatric Examination of Educational Readiness at Middle Childhood (Levine, 1985); MHT – Minnesota Handwriting Test (Reisman, 1993); THS – Test of Handwriting Skills (Grander, 1998); SFA – School Function Assessment (Coster, Deeney, Haltiwanger, & Haley, 1998); SMHP - Size Matters Handwriting Program (Moskowitz, 2009); *The Alphabet Beats* DVD (The TV Teacher, 2011); THS – R – the Test of Handwriting Skills – Revised (Milone, 2007); TMP – Test of Manual Pointing (von Hofsten & Rosblad, 1988); TPT - The Tactual Performance Test (Reitan & Wolfson, 1985); TVPS-3 - The Test of Visual Perceptual Skills—Third Edition; VMI – Visual- Motor Integration Test (Beery, 1997); WJIII - Woodcock-Johnson III Test of Achievement (McGrew, Schrank, & Woodcock, 2007); Zaner-Bloser (Zaner-Bloser, n.d.); ERGS – Error Recognition and Grading Scale (McClesky, 2004).

Table 3*Occupational Therapy Developed Handwriting Curriculum Examined in the Reviewed Studies*

Curriculum	Description
<i>Write Start</i> (Case-Smith, Holland, & Bishop, 2011)	Write Start is a model for teaching handwriting that can utilize any handwriting curricula. It emphasizes interprofessional teaching (occupational therapist, teacher, and learning specialist). Write Start includes weekly meetings between teacher and occupational therapist to review students' progress and lesson plans. Write Start encourages immediate feedback, positive reinforcement, self-evaluation, peer modeling, and term consistency when describing letter formation. Write Start utilizes small groups, station training, and whole class instruction.
<i>Handwriting Without Tears and Handwriting Without Tears-Get Set for School</i> (Olson, 2003)	Handwriting programs available for prewriting skills, printing, and cursive. Developmentally based and provides multisensory modalities to teach handwriting. HWT begins with developing posture and pencil grip, followed by readiness skills, and then actual writing tasks.
<i>Size Matters Handwriting Program</i> (Moskowitz, 2009)	Handwriting instruction with an emphasis on letter size. Explicit instructions are used to teach letter formation, spacing, placement on the line, and size. The program promotes self-assessment.
<i>Alphabet Beats DVD</i> (Chandler, Mulder, & Nall, 2014)	Video-based modeling instruction. Contains 5-minute chapters that feature lowercase letters. The sounds of each letter are introduced. A prompter models the strokes used to form the letters while verbally describing ("chanting") the direction of the strokes.
<i>LetterSchool</i> (Jordan, Michaud, & Kaiser, 2016)	Digital tablet application program that addresses fine-motor exercises, animated model, intrinsic feedback, and modeling.
<i>Write Direction</i> (Taras, Brennan, Gilbert, & Eck Reed, 2011)	Handwriting instruction designed to promote kinesthetic awareness of letter formation, letter stroke direction, fine motor dexterity, and visual-motor skills.

References

- Asher, A. V. (2006). Handwriting instruction in elementary schools. *American Journal of Occupational Therapy*, 60(4), 461-471. <https://doi.org/10.5014/ajot.60.4.461>
- Asher, A., & Estes, J. (2016). Handwriting instruction in elementary schools: Revisited! *Journal of Occupational Therapy, Schools, & Early Intervention*, 9(4), 353-365. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2016.1239560>
- Bazyk, S., & Cahill, S. (2014). School-based occupational therapy. In J. Case-Smith & J. C. O'Brien (Eds.), *Occupational therapy for children and adolescents* (7th ed., pp. 665–703). St. Louis: Elsevier Mosby.
- Bazyk, S., Michaud, P., Goodman, G., Papp, P., Hawkins, E., & Welch, M. A. (2009). Integrating occupational therapy services in a kindergarten curriculum: A look at the outcomes. *American Journal of Occupational Therapy*, 63(2), 160-171. <https://doi.org/10.5014/ajot.63.2.160>
- Blazer, C. (2010). Should cursive handwriting still be taught in schools. *Information Capsule*, 916(3), 1-8. <http://www.dadeschools.net>
- Bolton, T., & Plattner, L. (2020). Occupational therapy role in school-based practice: Perspectives from teachers and OTs. *Journal of Occupational Therapy, Schools, & Early Intervention*, 13(2), 136-146. <https://doiorg.proxy.library.nyu.edu/10.1080/19411243.2019.1636749>
- Cahill, S. M., McGuire, B., Krumdick, N. D., & Lee, M. M. (2014). National survey of occupational therapy practitioners' involvement in Response to Intervention. *American Journal of Occupational Therapy*, 68(6), e234-e240. <https://doi.org/10.5014/ajot.2014.010116>

Cahill, S. (2009). Where does handwriting fit in? Strategies to support academic achievement.

Intervention in School and Clinic, 44(4), 223-288.

<https://doi.org/10.1177/1053451208328826>

Carlson, K., & Cunningham, J. L. (1990). Effect of pencil diameter on the graphomotor skill of preschoolers. *Early Childhood Research Quarterly*, 5(2), 279-293.

[https://doi.org/10.1016/0885-2006\(90\)90049-7](https://doi.org/10.1016/0885-2006(90)90049-7)

*Case-Smith, J. (2002). Effectiveness of school-based occupational therapy intervention on handwriting. *American Journal of Occupational Therapy*, 56(1), 17-25.

<https://doi.org/10.5014/ajot.56.1.17>

Case-Smith, J., Holland, T., & Bishop, B. (2011). Effectiveness of an integrated handwriting program for first-grade students: A pilot study. *American Journal of Occupational Therapy*, 65(6), 670-678.

<https://doi.org/10.5014/ajot.2011.000984>

Case-Smith, J., Holland, T., Lane, A., & White, S. (2012). Effect of a coteaching handwriting program for first graders: One-group pretest–posttest design. *American Journal of Occupational Therapy*, 66(4), 396-405.

<https://doi.org/10.5014/ajot.2012.004333>

*Case-Smith, J., Holland, T., & White, S. (2014). Effectiveness of a co-taught handwriting program for first grade students. *Physical & Occupational Therapy in Pediatrics*, 34(1),

30- 43. <https://doi-org.proxy.library.nyu.edu/10.3109/01942638.2013.783898>

*Case-Smith, J., Weaver, L., & Holland, T. (2014). Effects of a classroom-embedded occupational therapist–teacher handwriting program for first-grade students. *American Journal of Occupational Therapy*, 68(6), 690-698.

<https://doi.org/10.5014/ajot.2014.011585>

* Candler, C., Mulder, A., & Nall, K. (2014). Embedding video-based modeling handwriting

- instruction in a Montessori preschool phonics program. *Journal of Occupational Therapy, Schools, & Early Intervention*, 7(2), 151-160. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2014.930618>
- *Chang, S. H., & Yu, N. Y. (2017). Visual and haptic perception training to improve handwriting skills in children with dysgraphia. *American Journal of Occupational Therapy*, 71(2), 7102220030p1-7102220030p10. <https://doi.org/10.5014/ajot.2017.021311>
- 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(2), 479-492. <https://doi.org/10.1348/000709906X116768>
- Collette, D., Anson, K., Halabi, N., Schlierman, A., & Suriner, A. (2017). Handwriting and common core state standards: Teacher, occupational therapist, and administrator perceptions from New York state public schools. *American Journal of Occupational Therapy*, 71(6), 7106220010p1-7106220010p9. <https://doi.org/10.5014/ajot.2017.021808>
- Cramm, H., & Egan, M. (2015). Practice patterns of school-based occupational therapists targeting handwriting: A knowledge-to-practice gap. *Journal of Occupational Therapy, Schools, & Early Intervention*, 8(2), 170-179. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2015.1040942>
- DaVanzo, D. L. (2018). *ADHD, handwriting, and mathematical ability in middle school boys* (Doctoral dissertation, California State University Dominguez Hills).
- Daly, C. J., Kelley, G. T., & Krauss, A. (2003). Relationship between visual-motor integration and handwriting skills of children in kindergarten: A modified replication study. *American Journal of Occupational Therapy*, 57(4), 459-462.

<https://doi.org/10.5014/ajot.57.4.459>

Dinehart, L. (2014). Handwriting in early childhood education: Current research and future implications. *Journal of Early Childhood Literacy*, 15(1), 97-118.

<https://doi.org/10.1177/1468798414522825>

Dinehart, L., & Manfra, L., (2013). Associations between low-income children's fine motor Skills in preschool and academic performance in second grade. *Early Education and Development*, 24(2), 138-161.

<https://doi-org.proxy.library.nyu.edu/10.1080/10409289.2011.636729>

*Denton, P. L., Cope, S., & Moser, C., (2006). The effects of sensorimotor-based intervention versus therapeutic practice on improving handwriting performance in 6 – 11-year-old children. *American Journal of Occupational Therapy*, 60, (1), 16-27.

<https://doi.org/10.5014/ajot.60.1.16>

Donica, D. (2010). A historical journey through the development of handwriting instruction (part 2): The occupational therapists' role. *Journal of Occupational Therapy, Schools, & Early Intervention*, 3(1), 32-53.

<https://doi-org.proxy.library.nyu.edu/10.1080/19411241003683995>

*Donica, D. K. (2015). Handwriting Without Tears: General education effectiveness through a consultative approach. *American Journal of Occupational Therapy*, 69, (6)

690610050p1-6906180050p8. <http://dx.doi.org/10.5014/ajot.2015.018366>

* Donica, D. K., Goins, A., & Wagner, L. (2013). Effectiveness of handwriting readiness programs on postural control, hand control, and letter and number formation in head start classrooms. *Journal of Occupational Therapy, Schools, & Early Intervention*, 6(2), 81-93. <https://doi.org/10.1080/19411243.2013.810938>

- *Donica, D., McCraw, S., Hudson, S., & Cason, J. (2013). Effectiveness of a structured multisensory handwriting curriculum on handwriting skills of kindergarten students. *Journal of Education Research*, 7(1), 1-15.
- Donica, D. K., Larson, M. H., & Zinn, A. A. (2012). Survey of handwriting instruction practices of elementary teachers and educational programs: Implications for occupational therapy. *Occupational Therapy in Health Care*, 26(2-3), 120-137. <https://doi-org.proxy.library.nyu.edu/10.3109/07380577.2012.693244>
- Donica, D. K., Massengill, M., & Gooden, M. J. (2018). A quantitative study on the relationship between grasp and handwriting legibility: Does grasp really matter? *Journal of Occupational Therapy, Schools, & Early Intervention*, 11(4), 411-425. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2018.1512068>
- Engel, C., Lillie, K., Zurawski, S., & Travers, B. G. (2018). Curriculum-based handwriting programs: A systematic review with effect sizes. *American Journal of Occupational Therapy*, 72(3), 7203205010p1-7203205010p8. <https://doi.org/10.5014/ajot.2018.027110>
- Engel-Yeger, B., Nagauker-Yanuv, L. & Rosenblum, S., (2009). Handwriting performance, self-reports, and perceived self-efficacy among children with dysgraphia. *American Journal of Occupational Therapy*, 63(2), 182-192. <https://doi.org/10.5014/ajot.63.2.182>
- Fancher, L. A., Priestley-Hopkins, D. A., & Jeffries, L. M. (2018). Handwriting acquisition and intervention: A systematic review. *Journal of Occupational Therapy, Schools, & Early Intervention*, 11(4), 454-473. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2018.1534634>
- Feder, K. & Majnemer, A. (2007). Handwriting development, competency, and intervention.

Developmental Medicine and Child Neurology, 49 (4), 312-317.

<https://doi.org/10.1111/j.1469-8749.2007.00312.x>

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in composing of elementary school students: A new methodological approach. *Journal of educational psychology*, 89(1), 170.

<https://doi.org/10.1037/0022-0663.89.1.170>

Graham, S., Harris, K. R., Fink-Chorzempa, B., & MacArthur, C. (2003). Primary grade teachers' instructional adaptations for struggling writers: A national survey. *Journal of Educational Psychology*, 95(2), 279. <https://doi.org/10.1037/0022-0663.95.2.279>

Graham, S., Harris, K. R., Mason, L., Fink-Chorzempa, B., Moran, S., & Saddler, B. (2008). How do primary grade teachers teach handwriting? A national survey. *Reading and Writing*, 21(1-2), 49-69. <https://doi.org/10.1007/s11145-007-9064-z>

Graham, S., & Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980 to 1994. *Educational Psychology Review*, 8(1), 7-87.

<https://doi.org/10.1007/BF01761831>

Grajo, L. C., Candler, C., & Sarafian, A. (2020). Interventions within the scope of occupational therapy to improve children's academic participation: A systematic review. *American Journal of Occupational Therapy*, 74(2), 7402180030p1-7402180030p32.

<https://doi.org/10.5014/ajot.2020.039016>

Greifeneder, R., Alt, A., Bottenberg, K., Seele, T., Zelt, S., & Wagener, D. (2010). On writing legibly: Processing fluency systematically biases evaluations of handwritten material.

Social Psychological and Personality Science, 1(3), 230-237.

<https://doi.org/10.1177/1948550610368434>

- Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behavior, 36*(2), 212-224.
<https://doi-org.proxy.library.nyu.edu/10.3200/JMBR.36.2.212-224>
- Halpin, G., & Halpin, G. (1976). Special paper for beginning handwriting an unjustified practice? *The Journal of Educational Research, 69*(7), 267-269.
<https://doi-org.proxy.library.nyu.edu/10.1080/00220671.1976.10884895>
- *Hape, K., Flood, N., McArthur, K., Sidara, C., Stephens, C., & Welsh, K. (2014). A pilot study of the effectiveness of the Handwriting Without Tears curriculum in first grade. *Journal Of Occupational Therapy, Schools, & Early Intervention, 7*(3-4), 284-293.
<https://doi.org/10.1080/19411243.2014.975071>
- Higgins, J. P. T., Altman, D. G., & Sterne, J. A. C. (2011). Assessing risk of bias in included studies. In J. P. T. Higgins & S. Green (Eds.), *Cochrane handbook for systematic reviews of interventions* (Version 5.1.0). London: Cochrane Collaboration. Retrieved from
<https://doi.org/10.1080/19411243.2014.975071>
- Howe, T. H., Roston, K. L., Sheu, C. F., & Hinojosa, J. (2013). Assessing handwriting intervention effectiveness in elementary school students: A two-group controlled study. *American Journal of Occupational Therapy, 67*(1), 19-26.
<https://doi.org/10.5014/ajot.2013.005470>
- Hoy, M. M. P., Egan, M. Y., & Feder, K. P. (2011). A systematic review of interventions to improve handwriting. *Canadian Journal of Occupational Therapy, 78*(1), 13 -25,
<https://doi.org/10.2182/cjot.2011.78.1.3>
- *Hunter, E., & Potvin, M. C. (2020). Effectiveness of a handwriting curriculum in kindergarten

- classrooms. *Journal of Occupational Therapy, Schools, & Early Intervention*, 13(1), 55-68. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2019.1647813>
- Hutton, E. (2009). Occupational therapy in mainstream primary schools: an evaluation of a pilot project. *British Journal of Occupational Therapy*, 72(7), 308-313.
<https://doi.org/10.1177/030802260907200707>
- Individuals with Disabilities Education Improvement Act of 2004, Pub. L. 108-446, 20
U.S.C Retrieved from: <http://www.ed.gov/policy/speced/guid/idea/idea2004.html>
- James, K., & Engelhardt, L., (2012). The effects of handwriting experience on functional brain development in pre-literate children. *Trends in Neuroscience and Education*, 1 (1) 32-42.
<https://doi.org/10.1016/j.tine.2012.08.001>
- * Jordan, G., Michaud, F., & Kaiser, M. L. (2016). Effectiveness of an intensive handwriting program for first grade students using the application LetterSchool: A pilot study. *Journal of Occupational Therapy, Schools, & Early Intervention*, 9(2), 176-184.
<https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2016.1178034>
- Kadar, M., Wan Yunus, F., Tan, E., Chai, S. C., Razaob, N. A., & Mohamat Kasim, D.
H. (2020). A systematic review of occupational therapy intervention for handwriting Skills in 4–6-year-old children. *Australian Occupational Therapy Journal*, 67(1), 3-12.
<https://doi.org/10.1111/1440-1630.12626>
- *Kaiser, M. L., Albaret, J. M., & Doudin, P. A. (2011). Efficacy of an explicit handwriting program. *Perceptual and Motor Skills*, 112(2), 610-618.
<https://doi.org/10.2466/11.25.PMS.112.2.610-618>
- Koziatek, S. M., & Powell, N. J. (2003). Pencil grips, legibility, and speed of fourth-graders' writing in cursive. *American Journal of Occupational Therapy*, 57(3), 284-288.

<https://doi.org/10.5014/ajot.57.3.284>

Law, M & MacFermid, J. (2014). Evidence-based Rehabilitation A Guide to Practice. (3rd ed., 384 -385). Slack Incorporated.

Lifshitz, N., & Har-Zvi, S., (2014). A comparison between students who receive and who do not receive a writing readiness intervention on handwriting quality, speed and positive reactions. *Early Childhood Education Journal*, 43(1), 47-55.

<https://doi.org/10.1007/s10643-013-0629-y>

Limpo, T. & Graham, S., (2020). The role of handwriting instruction in writers' education, *British Journal of Educational Studies*, 68(3), 311-329,

<https://doi-org.proxy.library.nyu.edu/10.1080/00071005.2019.1692127>

Lee, A. L., & Lape, J. E. (2020). A Cognitive, self-monitoring intervention for handwriting with second-grade students. *Journal of Occupational Therapy, Schools, & Early Intervention*, 13(2), 170-185.

<https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2019.1672604>

Longcamp, M., Zerbato-Poudou, M. T., & Velay, J. L. (2005). The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing. *Acta Psychologica*, 119(1), 67-79. <https://doi.org/10.1016/j.actpsy.2004.10.019>

*Lust, C. A., & Donica, D. K. (2011). Effectiveness of a handwriting readiness program in Head Start: A two-group controlled trial. *American Journal of Occupational Therapy*, 65(5), 560-568. <https://doi.org/10.5014/ajot.2011.000612>

Maldarelli, J.E., Kahrs, B. A., Hunt, S.C., & Lockman, J. J. (2015). Development of early handwriting: Visual-motor control letter copying. *Developmental Psychology*, 51(7), 879-889 <https://doi.org/10.1037/a0039424>

- McCarroll, H., & Fletcher, T. (2017). Does handwriting instruction have a place in the instructional day? The relationship between handwriting quality and academic success. *Cogent Education*, 4(1), 1-10.
<https://doi.org/10.1080/2331186X.2017.1386427>
- McCutchen, D. (1996). A capacity theory of writing: Working memory in composition. *Educational Psychology Review*, 8(3), 299-325.
- Medwell, J., & Wray, D. (2008). Handwriting—A forgotten language skill?. *Language and Education*, 22(1), 34-47. <https://doi-org.proxy.library.nyu.edu/10.2167/le722.0>
- Medwell, J., & Wray, D. (2014). Handwriting automaticity: The search for performance thresholds. *Language and Education*, 28(1), 34-51.
<https://doi-org.proxy.library.nyu.edu/10.1080/09500782.2013.763819>
- Medwell, J., & Wray, D. (2007). Handwriting: what do we know and what do we need to know?. *Literacy*, 41(1), 10-15. <https://doi.org/10.1111/j.1467-9345.2007.00453.x>
- Medwell, J., Strand, S., & Wray, D. (2009). The links between handwriting and composing for Y6 children. *Cambridge journal of education*, 39(3), 329-344.
<https://doi-org.proxy.library.nyu.edu/10.1080/03057640903103728>
- Moskowitz, B., Carswell, B., Kitzmiller, J., Bushell, M., Neikrug, L., Gottesman, C., ... & Murray, T. (2017). The effectiveness of the Size Matters Handwriting Program. *American Journal of Occupational Therapy*, 71(4_Supplement_1), 7111520304p1-7111520304p1. <https://doi.org/10.5014/ajot.2017.71S1-PO5147>
- Moskowitz, B. (2009). Handwriting club (Unpublished doctoral dissertation). *Temple University: Philadelphia, PA*.
- National Governors Association Center for Best Practices, Council of Chief State School

- Officers. (2021). *Common Core State Standards*. Washington, D.C: National Governors Association Center for Best Practices, Council of Chief State School.
- <http://www.corestandards.org/ELA-Literacy/>
- Nye, J. A., & Sood, D. (2018). Teachers' perceptions of needs and supports for handwriting instruction in kindergarten. *The Open Journal of Occupational Therapy*, 6(2) 1-12.
- <https://doi.org/10.15453/2168-6408.1411>
- Oehler, E. Dekrey, H., Eadry, E., Fogo, J., Lewis, E., Maher, C., & Schilling, A. (2000). The effect of pencil size and shape on the pre-writing skills of kindergartners, *Physical & Occupational Therapy in Pediatrics*, 19(3-4), 53-60,
- https://doi.org/10.1080/J006v19n03_05
- Ohl, A. M., Graze, H., Weber, K., Kenny, S., Salvatore, C., & Wagreich, S. (2013). Effectiveness of a 10-week Tier-1 Response to Intervention program in improving fine motor and visual-motor skills in general education kindergarten students. *American Journal of Occupational Therapy*, 67(5), 507-514.
- <https://doi.org/10.5014/ajot.2013.008110>
- Olsen, J. (2003). *Handwriting Without Tears*. Cabin John, MD: Western Psychological Services.
- Olsen, Jan Z., Emily F. Knapton, and Edith H. Fine. *Handwriting without tears*. Handwriting Without Tears, 2008.
- *Peterson, C. Q., & Nelson, D. L. (2003). Effect of an occupational intervention on printing in children with economic disadvantages. *American Journal of Occupational Therapy*, 57(2), 152-160. <https://doi.org/10.5014/ajot.57.2.152>
- *Pfeiffer, B., Moskowitz, B., Paoletti, A., Brusilovskiy E, Zylstra, S., & Murray, T.

- (2015). Developmental test of Visual Motor Integration (VMI): an effective outcome measure for handwriting interventions for kindergarten, first-grade, and second-grade students? *American Journal of Occupational Therapy*, 69(4), 6904350010p1-6904350010p7. <https://doi.org/10.5014/ajot.2015.015826>
- *Pfeiffer, B., Rai, G., Murray, T., & Brusilovskiy, E. (2015). Effectiveness of the Size Matters Handwriting Program. *OTJR: Occupation, Participation and Health*, 35(2), 110-119. <https://doi.org/10.1177/1539449215573004>
- Piller, A., & Torrez, E. (2019). Defining occupational therapy interventions for children with fine motor and handwriting difficulties. *Journal of Occupational Therapy, Schools, & Early Intervention*, 12(2), 210-224. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2019.1592053>
- Prunty, M. M., Barnett, A. L., Wilmut, K., & Plumb, M. S. (2013). Handwriting speed in children with developmental coordination disorder: Are they really slower? *Research In Developmental Disabilities*, 34(9), 2927-2936. <https://doi.org/10.1016/j.ridd.2013.06.005>
- Randall, B. S. (2018). Collaborative instruction and Handwriting Without Tears: A strong foundation for kindergarten learning. *Journal of Occupational Therapy, Schools, & Early Intervention*, 11(4), 374-384. <https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2018.1476200>
- *Ratzon, N. Z., Efraim, D., & Bart, O. (2007). A short-term graphomotor program for improving writing readiness skills of first-grade students. *American Journal of Occupational Therapy*, 61(4), 399-405. <https://doi.org/10.5014/ajot.61.4.399>
- Reidlinger, W., Candler, C., & Neville, M. (2012). Comparison of differently lined paper on

letter production quality in first graders. *Journal of Occupational Therapy, Schools, & Early Intervention*, 5(2), 155-164.

<https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2012.701544>

*Roberts, G. I., Derkach-Ferguson, A. F., Siever, J. E., & Rose, M. S. (2014). An examination of the effectiveness of Handwriting Without Tears instruction: Examen de l'efficacité du Programme Handwriting Without Tears. *Canadian Journal of Occupational Therapy*, 81(2), 102-113. <https://doi.org/10.1177/0008417414527065>

Rogers, J., & Case-Smith, J. (2002). Relationships between handwriting and keyboarding performance of sixth-grade students. *American Journal of Occupational Therapy*, 56(1), 34-39. <https://doi.org/10.5014/ajot.56.1.34>

Roston, K. L., Hinojosa, J., & Kaplan, H. (2008). Using the Minnesota Handwriting Assessment and Handwriting Checklist in screening first and second graders' handwriting legibility. *Journal of Occupational Therapy, Schools, & Early Intervention*, 1(2), 100-115. <https://doi.org/10.1080/19411240802312947>

Rosenblum, S., Dvorkin, A. Y., & Weiss, P. L. Automatic segmentation as a tool for examining the handwriting process of children with dysgraphic and proficient handwriting. *Human Movement Science*, 25(4-5), 608-621. <https://doi.org/10.1016/j.humov.2006.07.005>

Santangelo, T., & Graham, S. (2016). A comprehensive meta-analysis of handwriting instruction. *Educational Psychology Review*, 28(2), 225-265. <https://doi.org/10.1007/s10648-015-9335-1>

Sackett, D. L., Rosenberg, W. M., Muir Gray, J. A., Haynes, R. B., & Richardson. (1996). Evidence based medicine: What it is and what it isn't. *British Medical Journal*, 312, pp. 71-72. <https://doi.org/10.1136/bmj.312.7023.71>

Schneck, C.M. & Amundson, S. J. (2010). Prewriting and Handwriting Skills. In Case-Smith, 6th Edn., J. & O'Brien, J. C. (Eds.), *Occupational Therapy for Children* (pp:555-582). St. Louis, MO.: Mosby/Elsevier, ISBN-13: 9780323056588.

Schneck, C. M., & Henderson, A. (1990). Descriptive analysis of the developmental progression of grip position for pencil and crayon control in nondysfunctional children. *American Journal of Occupational Therapy*, 44(10), 893-900.
<https://doi.org/10.5014/ajot.44.10.893>

*Schneck, C., Shasby, S., Myers, C., & Depoy Smith, M. L. (2012). Handwriting without tears versus teacher-designed handwriting instruction in first grade classrooms. *Journal of Occupational Therapy, Schools, & Early Intervention*, 5(1), 31-42.
<https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2012.675759>

Schwellnus, H., Carnahan, H., Kushki, A., Polatajko, H., Missiuna, C., & Chau, T. (2013). Writing forces associated with four pencil grasp patterns in grade 4 children. *American Journal of Occupational Therapy*, 67(2), 218-227.
<https://doi.org/10.5014/ajot.2013.005538>

Seruya, F. M., & Garfinkel, M. (2020). Caseload and workload: Current trends in school-based practice across the United States. *American Journal of Occupational Therapy*, 74(5), 7405205090p1-7405205090p8. <https://doi.org/10.5014/ajot.2020.039818>

Seruya, F. M., & Garfinkel, M. (2018). Implementing contextually-based services: Where do we begin? *SIS Quarterly Practice Connections*, 3(3), 4–7

Smits-Engelsman, B. M. C., Niemeijer, A.S., & Van Galen, G. P. (2001). Fine motor deficiencies in children diagnosed as DCD based on poor graph-motor ability. *Human Movement Science* 20(1-2), 161- 182. [https://doi.org/10.1016/S0167-9457\(01\)00033-1](https://doi.org/10.1016/S0167-9457(01)00033-1)

Son, S. H., & Meisels, S. J. (2006). The relationship of young children's motor skills to later reading and math achievement. *Merrill-Palmer Quarterly* 15(4), 755-778.

<https://www.jstor.org/stable/23096032>

*Taras, H., Brennan, J., Gilbert, A., & Eck Reed, H. (2011). Effectiveness of occupational therapy strategies for teaching handwriting skills to kindergarten children. *Journal of Occupational Therapy, Schools, & Early Intervention*, 4 (3-4), 236-246.

<https://doi-org.proxy.library.nyu.edu/10.1080/19411243.2011.629554>

US Preventive Services Task Force, United States. Office of Disease Prevention, & Health Promotion. (1996). *Guide to clinical preventive services: report of the US Preventive Services Task Force*. US Department of Health and Human Services, Office of Public Health and Science, Office of Disease Prevention and Health Promotion.

*Weintraub, N., Yinon, M., Hirsch, I. B. E., & Parush, S. (2009). Effectiveness of sensorimotor and task-oriented handwriting intervention in elementary school-aged students with handwriting difficulties. *OTJR: Occupation, Participation and Health*, 29(3), 125-134.

<https://doi.org/10.3928/15394492-20090611-05>

Woodward, S., & Swinth, Y. (2002). Multisensory approach to handwriting remediation: perceptions of school-based occupational therapists. *American Journal of Occupational Therapy*, 56(3), 305-312. <https://doi.org/10.5014/ajot.56.3.305>

Ziviani, J. (1981). Effects of pencil shape and size on motor accuracy and pencil posture of 8 year old children.

*Zwicker, J. G., & Hadwin, A. F. (2009). Cognitive versus multisensory approaches to handwriting intervention: A randomized controlled trial. *OTJR: Occupation,*

Participation and Health, 29(1), 40-48. <https://doi.org/10.1177/153944920902900106>

- * Zylstra, S. E., & Pfeiffer, B. (2016). Effectiveness of a handwriting intervention with at-risk kindergarteners. *American Journal of Occupational Therapy*, 70(3), 7003220020p1-7003220020p8. <https://doi.org/10.5014/ajot.2016.018820>

*Indicates articles included in the systematic review