# Effectiveness of the Size Matters Handwriting Program

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**Abstract**

The purpose of the research was to study changes in handwriting legibility among kindergarten, first- and second-grade students in response to the Size Matters curricular-based handwriting program. A two-group pre–post-test design was implemented at two public schools with half of the classrooms assigned to receive the Size Matters program and the other continuing to receive standard instruction. All participants completed two standardized handwriting measures at pre-test and after 40 instructional sessions were completed with the classes receiving the handwriting program. Results identified significant changes in legibility in the handwriting intervention group for all three grades when compared with the standard instruction group. The results of this study support the use of a curricular-embedded handwriting program and provide the foundation for future research examining the impact of handwriting legibility on learning outcomes.

**Keywords**

handwriting, handwriting curriculum, handwriting intervention, Size Matters

Handwriting is an essential life skill. It involves a complex integration of several body systems, requires extensive training to master, and is a necessary functional task for school-aged children. It is the primary means by which students express, communicate, and record ideas (Erhardt & Meade, 2005). Past and current research on handwriting supports the notion that left unaddressed, poor handwriting affects children's academic performance, self-esteem, and success at school and in life (Berninger et al., 2006; Engel-Yeger, Nagauker-Yanuv, & Rosenblum, 2009; Feder, Majnemer, Bourbonnais, Blayney, & Morin, 2007). Therefore, early identification and remediation of handwriting deficiencies before children reach middle and high school, when handwriting demands increase in complexity and intensity, can prevent difficulties associated with handwriting (Ste-Marie, Clark, Findlay, & Latimer, 2004).

Few activities in school are exempt from proficient handwriting. Elementary students spend 30% to 60% of the day writing in math, reading, spelling, social studies, and science (Volman, van Schendel, & Jongmans, 2006). Furthermore, handwriting difficulties do not resolve without intervention (Feder et al., 2007). Yet in spite of large portions of schoolwork requiring writing, handwriting instruction is on the decline.

The mechanics of handwriting is a focus in early grades. However by second grade, attention shifts to the cognitive aspects of writing. Most primary schools no longer have formal handwriting programs. Among surveyed first- to third-grade teachers, 12% reported adequate preparation to teach handwriting, and only 39% felt that their students' handwriting was adequate. Twenty-five percent reported that students experienced difficulty with handwriting, and 46% indicated that their students' speed was insufficient to keep up with classroom demands (Graham et al., 2008).

Arguments for teaching handwriting include studies on brain activation. James and colleagues mapped the brains of preliterate and school-aged children through magnetic resonance imagery (MRI) during letter writing versus letter recognition tasks (James, 2009; James & Gauthier, 2009). In one study, two groups of pre-schoolers were shown letters, but only one group was taught how to write them. After 4 weeks, the group taught how to write letters showed a dramatic increase in neural activation in the visual association cortex. James (2009) concluded that printing practice affects interactions among sensorimotor systems, leading to functional specialization. In another study (James & Engelhardt, 2012), 5-year-olds printed, typed, or traced letters, then were shown images of these same letters while undergoing functional MRI scanning. The results showed that a previously established "reading circuit"' was activated during letter

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perception only after handwriting, but not after typing or tracing. This observation supported the hypothesis that letter perception recruits components of the reading systems in the brain more than other forms of sensorimotor practice.

Occupational therapists support classroom teachers using activities and programs to remediate handwriting. Although the Individual With Disabilities Act (IDEA) encourages service in the least restrictive environment, research is minimal regarding inclusive occupational therapy (OT). While there are several handwriting programs, research is inconsistent regarding the effectiveness. One widely used program, Handwriting Without Tears (HWT), uses a multisensory approach. Although research supporting its efficacy is just emerging, a recent study (Roberts, Derkach-Ferguson, Siever, & Rose, 2014) found a significant change in handwriting skills after using the HWT program embedded into the classroom curriculum. These findings contribute to the evidence supporting curriculum-embedded instruction. Marr and Dimeo (2006) investigated the effectiveness of HWT when implemented in a pull out model. Results identified significant changes in the formation of both upper- and lowercase alphabets but no changes in copying, dictation, composition, and legibility scores. Kiss (2007) used HWT and demonstrated improvement in only the legibility score of the Minnesota Handwriting Assessment (MHA). Case-Smith, Holland, and Bishop (2011) and Case-Smith, Holland, Lane, and White (2012) investigated the effectiveness of Write Start, an integrated handwriting program, for first graders. Large gains made in handwriting legibility, speed, and fluency were maintained throughout the school year. The Write Start program is an embedded co-teaching intervention. The occupational therapist and teacher collaborate to provide handwriting and writing instruction.

Schneck, Shasby, Myers, and DePoy Smith (2012) compared teacher instruction versus HWT in the first grade. The first group learned HWT, and the second group learned a teacher-designed program and random practice. A significant change was noted in the second group that used a more task-oriented versus a sensorimotor approach. The use of task-oriented approaches, which incorporate specific skill training and motor learning concepts, has demonstrated promise in other research (Ste-Marie et al., 2004). Mackay, McCluskey, and Meyers (2010) examined the effects of the Log Handwriting Program comprised of repetition, systematic skill building, task-oriented practice, homework, verbal prompts, and modeling to improve legibility. Sixteen first and second graders participated in the handwriting program for 45 min/week over 8 weeks. The students in the Log Handwriting Program showed statistically significant improvements in legibility, form, alignment, size, and spacing. Speed, however, decreased.

The Size Matters Handwriting Program (SMHP) was used as the primary intervention for the current study. It uses a systematic child-centered approach, explicit instructions, and motor learning origins, making it easy to embed within the school curriculum. These are all factors identified as effective in improving handwriting legibility.

Developed by an occupational therapist, SMHP is cost-effective, efficient, and measurable. This is important because limited teacher training, budgets, time, and materials have contributed to increased referrals to response to intervention (RTI) and occupational therapy relative to handwriting. As SMHP is concept-driven, it can be implemented with no materials other than the knowledge. This facilitates teacher follow through and student carryover.

The greatest difference between SMHP and other handwriting instructional programs is the shift in focus from letter form to letter size. Correcting errors in letter size has been observed to make an immediate difference in the consistency and readability of the written page. SMHP's practice progresses from blocked and constant to random and variable, reflecting motor learning theory (Schmidt & Wrisberg, 2004). In addition, it incorporates direct instruction, memorable mnemonics, motivational incentives, frequent visual cuing, parent involvement, self-critiquing, and self-monitoring.

In summary, occupational therapists are instrumental in developing handwriting programs. To date, handwriting remains the Number 1 referral issue for OT in schools (Asher, 2006; Marr & Dimeo, 2006). The purpose of this study was to determine whether a curricular-based handwriting program (SMHP) is effective in improving legibility, as well as to establish proof of evidence for its use in future effectiveness studies targeting academic and learning outcomes.

## Method

### *Research Design*

A two-group pre–post-test design was implemented at two public schools to investigate the effect of the SMHP on handwriting legibility in kindergartners, and first and second graders. An urban school in Massachusetts randomized classroom assignment to either treatment or non-treatment control groups. The principal investigator used random selection as there were multiple classrooms per grade. A rural upstate New York school used convenience assignments due to teacher availability.

### *Participants*

Kindergarten through second-grade students in two regular education public schools participated in the study. Half of the classrooms received the treatment, whereas the other half had no intervention other than typical classroom instruction. There were two classrooms that participated in the study in each grade and each school, for a total of 12 classes. All students were in regular education classrooms with a small percentage (kindergarten 3.64%, first grade 4.0%, and second grade 5.13%) having an Individualized Education Plan (IEP).

Inclusive of children with 504 service plans receiving OT, those percentages increased to 10.67% in first and 12.5% in second grades.

There were 207 students altogether. In all, 93 were from New York and 114 from Massachusetts, for a combined total of 55 kindergarteners, 74 first graders, and 78 second graders. An additional five children moved prior to completing study interventions and post-testing.

## Outcome Measures

*The Test of Handwriting Skills–Revised (THS-R).* The THS-R (Milone, 2007) is a standardized, norm-referenced assessment of manuscript, cursive and numbers. It is intended for use with students aged 6 through 18. The manuscript domain was used for this study. The THS-R has a test–retest reliability of .82 and a high agreement among raters (0.59-1.00) with typical responses ranging from 0.75 to 0.90. The THS-R is a standardized handwriting assessment (Milone, 2007).

Only 9 of the 10 subtests in the THS were used. The first two, THS-Airplane and THS-Bus, require alphabet writing from memory, uppercase then lower. The next two subtests, THS-Butterfly and THS-Frog, require alphabet writing from dictation, upper then lower. THS-Tree and THS-Horse subtests are letter copying tests. In THS-Truck subtest, participants copied words, and for the THS-Book, they copied sentences. Finally, in THS-Lion, students write words from dictation.

On each subtest, letters earned a score between 0 (worst) and 3 (best), based on the presence or absence of distortions; missing or added parts; inappropriate angles or curves; extra, missing, or unattached lines; incorrect angles; incorrect letter case; or touching of other letters. Missing letters got 0 scores. A series of sample charts illustrated common mistakes and scoring. The scores for each letter were summed to calculate the total subtest score. Reference scales ranging between 1 and 19 represented a population distribution with a mean of 10 and a standard deviation of 3. As the study involved 5-year-old students and the THS-R norms start at age 6, the lowest norms available were used with these students. This was considered acceptable as the scores were analyzed to measure individual change scores. The THS-R manual provided detailed scoring instructions.

The THS-R is an untimed test and was administered in a group. Components of the THS-R were used in all three grades. The original THS-R booklet has pictures on otherwise blank pages to eliminate letter cuing. As letter size is the key component of the intervention being measured, a modified lined paper was used, appropriate in scale for each grade. Kindergarten students completed THS-R subtests measuring uppercase letters. First-grade students completed subtests measuring lowercase letters. Second graders were tested on all upper- and lowercase letters. The choice of subtests was based on the specific focus of handwriting instruction provided to each grade in the intervention program.

*The MHA.* The MHA (Reisman, 1999) is a norm-referenced assessment of manuscript handwriting. It can be used from January of first grade through second grade. The MHA tests speed and provides scores for rate, legibility, form, alignment, size, and spacing. The interrater reliability rate for the MHA for inexperienced raters is between .87 (form) and .98 (alignment and size), while for experienced raters, it is between .90 (form) and .99 (alignment and size). The intrarater reliability is between .97 and 1.00. Test–retest reliability is .62 (legibility) to .89 (alignment and size; Reisman, 1999). For the study, the MHA was administered in a group setting to only first and second graders.

In the MHA, children copy "the quick brown fox jumped over the lazy dogs," with words rearranged to reduce the disadvantage for poorer readers. Copying lines are clearly marked with reference lines above and below. Six scores were calculated including rate, which is the number of letters copied in 2.5 min. The total letter count is 34. The remaining scales judged legibility, form, alignment, size, and spacing, starting with a score of 34 on each. A point was subtracted on the legibility scale, if letters looked like several at once, or were omitted, unrecognizable, reversed or rotated, incomplete, or capitalized. Points were lost on form for inappropriate curvatures or sharp edges, extensions or elongations, extra lines, dents, or gaps. Letters not within 1/16 inch above or below the baseline lost alignment points; those that were not within 1/16 inch above or below the lower and upper reference lines lost a size point. A point on the spacing scale was lost if there was too little or too much space. Illegible letters automatically lost a point on the form, alignment, size, and spacing.

*Demographic form*. Each classroom teacher completed a demographic form providing information on age, gender, grade, hand use, diagnoses, and students who had previous formal handwriting instruction, individual education plans, or occupational therapy services.

## Procedures

The Institutional Review Board at the primary investigator's university approved the study protocol. Formal approval was obtained from school administrators with permission forms signed by caregivers. Prior to baseline testing, teachers were provided with fidelity manuals and taught how to implement SMHP during in-services. The manuals included detailed directions for daily lessons as well as tips on scoring, key concepts, and verbal cuing. Site managers were occupational therapists with specialized training in the SMHP. They were onsite several times per week to provide support and answer questions. Kindergarten teachers from the experimental group received student workbooks. Experimental group teachers in first and second grade received other SMHP materials. The control group received no materials during the study but were given access to the program after data collection was completed.

**Table 1.** Size Matter Handwriting Intervention Concepts.

| Concept | Description |
|---|---|
| Writing line names | The names for the writing lines are top line, middle or dotted line, and bottom line. The adapted paper used has a thick bottom line as it is believed that it is harder to stop than start writing. There is no descender line, but there is a large skip space between writing lines. Go lines (i.e., left margin lines) and Finish lines (i.e., right margin lines) cue left to right progression and letter formations. |
| Letter line names | The six different letter line names refer to the orientation of the pencil marks and the movement of the pencil. These include standing tall lines, lying down lines, slant lines, Super C lines, smiles and frowns, and clock lines. |
| Starting points | All letters start at the top or dotted lines excepting e and f. |
| Touch points | Touch points describe the connection between the pencil stroke and the writing or letter lines. Precision touch points determine if letters are printed the correct size. |
| Super C | Super C letters are always initial lines made by making a backward rounded stroke. These are more commonly reversed than other letters. Super C is a super hero character that models correct directionality. |
| Stars and dice game | Students earn stars when their letters are the right size. If a letter is an incorrect size, starts at the bottom, or uses the wrong letter line, students roll dice to determine how many times they need to practice printing a letter correctly. Dice can determine practice or remediation. It enables students to feel in control. |
| Letter size | Letters are either Size 1, 2, or 3. Size 1 letters have to touch the top and bottom lines without exceeding above or below the lines or floating in the middle. All uppercase letters and numbers are Size 1. Size 2 letters must touch the dotted and bottom line without floating. Size 3 letters touch the dotted line and go below the bottom line. If they have a "belly," it has to sit on the bottom line. |
| Spaghetti and meatballs | This kid-friendly concept illustrates spacing of letters and words. A yellow pencil is used to draw a thin spaghetti line between letters. There should be room for only one. A red pencil is used to draw meatballs between words. These should be of equal diameter. |

Pretest data included scores from the THS-R, MHA, and student demographic forms. The intervention phase included forty 20-min sessions. The control group teachers used an informal approach to instruction, encouraging neatness and legibility and providing desktop and classroom references. The amount of time devoted to instruction was comparable between groups. Post-testing followed using the same outcome measures. Eleven occupational therapists and graduate students from six states scored the assessments. Interrater reliability testing for all raters was established at a minimum of .80 prior to scoring.

## *Intervention*

SMHP was developed to improve handwriting legibility in students of all ability levels by embedding teacher and kid-friendly strategies, sound bites and scoring into the curriculum. The Rules are a simple song and dance that identifies the writing lines to be touched. Star-Worthy letters are those that touch the writing lines in all the right places. The total number of letters earning Stars is divided by the total number of letters written, yielding a percentage of size accuracy. The Dice Game determines practice and reminds children to "Think Letter Size." Adapted writing paper is graded and has thickened bottom lines and dotted middle lines. Graduation to a higher grade-level paper is an incentive to print accurately sized letters. For the purposes of this study, SMHP focused on manuscript fonts only. There are eight key concepts in the program, including (a) writing lines, (b) letter lines, (c) starting points, (d) touch points, (e) Super C, (f) stars and dice game, (g) letter size, and (h) spaghetti and meatballs. A description of each concept is provided in Table 1.

The main emphasis of SMHP is letter size. Size 1 letters touch the top and bottom lines, and cannot float in the middle (i.e., b, d, f, h, k, l, t, and all capital letters). Size 2 letters touch the dotted and bottom line without floating (i.e., a, c, e, i, m, n, o, r, s, u, v, w, x, and z), and Size 3 letters touch the dotted line and go below the bottom line (i.e., g, j, p, q, y). SMHP contends that uniformly sized letters are not only easy to teach but will also result in more legible text. The kindergarten classroom focused on Size 1 uppercase letters. First grade focused on lowercase, first Size 1, 2, then 3. Second grade focused on both. Spacing, while also a focus of SMHP, is addressed once students achieve 80% accuracy in size. However, because of time constraints, it was not a focus of this study.

Classroom teachers implemented a 20-min lesson 5 days a week at their convenience. Kindergarten instruction emphasized the Size 1 rule and uppercase letters. This was followed by direct instruction on how to form one uppercase letter per day. Following a common directionality of stroke sequence instruction progressed from letters with vertical lines to horizontal, single curves, double curves, and slant lines. Reminders to make letters the correct size were voiced throughout the day. At the end of each week, there were review lessons of all letters learned.

First-grade instruction emphasized lowercase letter legibility. Their 40-day program began by teaching the eight key concepts of the program, followed by direct instruction of the three letter sizes. The sequence of instruction was based

**Table 2.** Demographic Characteristics Prior to Intervention.

| | Kindergarteners[a] | | First graders[a] | | Second graders[a] | | Whole sample[a] | |
|---|---|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | *N* | % | *N* | % |
| Site | | | | | | | | |
| New York | 23 | 41.8 | 32 | 43.2 | 38 | 48.7 | 93 | 44.9 |
| Massachusetts | 32 | 58.2 | 42 | 56.8 | 40 | 51.3 | 114 | 55.1 |
| Age | | | | | | | | |
| 5 | 45 | 81.8 | 0 | 0 | 0 | 0 | 45 | 21.7 |
| 6 | 10 | 18.2 | 61 | 82.4 | 0 | 0 | 71 | 34.3 |
| 7 | 0 | 0 | 12 | 16.2 | 59 | 75.6 | 71 | 34.3 |
| 8 | 0 | 0 | 1 | 1.4 | 19 | 24.4 | 20 | 9.7 |
| Gender | | | | | | | | |
| Male | 23 | 41.8 | 31 | 41.9 | 33 | 42.3 | 87 | 42 |
| Female | 32 | 58.2 | 43 | 58.1 | 45 | 57.7 | 120 | 58 |
| Hand orientation | | | | | | | | |
| Right handed | 48 | 87.3 | 66 | 89.2 | 74 | 94.9 | 188 | 90.8 |
| Left handed | 7 | 12.7 | 8 | 10.8 | 4 | 5.1 | 19 | 9.2 |
| With Individualized Education Plan | 2 | 3.6 | 3 | 4.1 | 4 | 5.1 | 9 | 4.4 |
| Have a diagnosis | 1 | 1.8 | 7 | 9.5 | 10 | 12.8 | 18 | 8.7 |
| Receiving occupational therapy | 2 | 3.6 | 8 | 10.8 | 9 | 11.5 | 19 | 9.2 |

[a]No significant baseline differences between experimental and control groups on any variable for kindergarten, first-grade, and second-grade students, and for the whole sample.

on size. Letters continued alphabetically in their respective letter size with a few exceptions. For example, b and d were separated as they are letters that students often confuse. Next, Super C Size 2 letters were taught emphasizing that these letters are not only Size 1, 2, or 3, but were also Super Cs, meaning that the letter started with a C. Each week reviewed already taught letters. Audible reminders (i.e., The Dice Game) happened at the discretion of the teacher throughout the day.

Second-grade instruction focused on Size 1 uppercase letters first, and then all sizes of lowercase letters. Their 40-day program also began by teaching students the eight key concepts. Second-grade students followed the same order as kindergarten and first grade. However, they were taught several letters per day. They also reviewed letters practiced at the end of each week and played the Dice Game throughout the day.

The control groups continued their standard instructional practices for handwriting in school. These varied between school districts and grades. Control group teachers discussed letter formation based on an eclectic mix of styles depending upon teacher experience or current literacy programs. Letters were taught in an alphabetical sequence. Verbal cuing varied between classes and was used when letters were introduced. After that, letter formations that continued to be difficult were modeled as they appeared in a lesson. Teachers were consistent with their own lessons but not between classes within or between schools.

Alphabet strips were located above the board at the front of the room. Kindergarteners and first graders used practice paper with a dashed middle line. Some teachers issued paper with icons in the left margin to help children remember the writing lines. Many second-grade teachers used regular ruled paper. Mention of the writing lines was incidental to the lesson but not emphasized. There were no workbooks.

### *Data Analysis*

Chi-square tests and independent samples *t* tests were used prior to the intervention to examine differences between grades, the experimental and control groups, demographics and outcome measures. A difference-in-difference approach and independent samples *t* test were used to compare change scores by both groups from their pre-intervention scores to their post-intervention. These analyses were done separately for each grade level, and a Bonferroni correction was applied to account for multiple tests.

## Results

### *Demographics*

A total of 207 children participated in the study. In all, 55 (26.57%) were in kindergarten, 74 (35.75%) were in first grade, and the remaining 78 (37.68%) were in second grade. Table 2 shows their demographic characteristics by school year. Of the 207-person sample, 44.93% attended school in New York and 55.07% in Massachusetts. All children were between 5 and 8 years old, with older children in higher grades. More than half of the sample were female (57.97%),

**Table 3.** Pre-Intervention Scores for the Whole Sample (Experimental and Control Groups Combined) by Grade Level.

| | Kindergarten | | | First grade | | | Second grade | | |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *N* | *M* | *SD* |
| MHA | | | | | | | | | |
| Rate | | | | 74 | 32.9 | 3.3 | 78 | 33.6 | 2.2 |
| Legibility | | | | 74 | 32.2 | 3.6 | 78 | 32.5 | 1.8 |
| Form | | | | 74 | 27.0 | 4.8 | 78 | 27.4 | 4.3 |
| Alignment | | | | 74 | 25.0 | 6.9 | 78 | 27.4 | 5.3 |
| Size | | | | 74 | 22.3 | 8.2 | 78 | 19.5 | 9.0 |
| Spacing | | | | 74 | 30.5 | 4.9 | 78 | 31.2 | 4.4 |
| THS—Scaled | | | | | | | | | |
| Airplane | 55 | 7.4 | 3.7 | | | | 78 | 11.5 | 3.0 |
| Bus | | | | 74 | 10.6 | 3.0 | 78 | 12.6 | 3.3 |
| Butterfly | 55 | 6.9 | 2.8 | | | | 78 | 11.6 | 3.0 |
| Frog | | | | 74 | 11.4 | 2.7 | 78 | 12.7 | 2.7 |
| Tree | 55 | 7.8 | 4.1 | | | | 78 | 11.9 | 2.8 |
| Horse | | | | 74 | 11.4 | 4.2 | 78 | 12.6 | 3.5 |
| Truck | | | | 74 | 11.2 | 4.1 | 78 | 12.9 | 3.0 |
| Book | | | | 74 | 11.2 | 3.9 | 78 | 13.5 | 3.1 |
| Lion | | | | 74 | 10.3 | 3.6 | 78 | 12.7 | 3.1 |

*Note.* Prior to the intervention, no significant differences were found between the experimental and control groups on any measures for kindergarten and second-grade students. Pre-intervention differences between experimental and control conditions were found for first graders on MHA size and THS-Lion. These differences disappear after the Bonferroni correction is applied. MHA = Minnesota Handwriting Assessment; THS = Test of Handwriting Skills.

with similar gender distributions in each grade. The vast majority of the students were right handed, ranging from 87.27% in kindergarten to 94.87% in second grade. A small proportion of the sample, ranging from 3.64% in kindergarten to 5.13% in second grade, had an IEP. Less than a tenth of the sample had a diagnosed health problem (e.g., attention-deficit/hyperactivity disorder [ADHD]), and less than a tenth received occupational therapy services, although both proportions increased with the grade level.

## *Pre-Intervention Scores*

Chi-square tests showed no statistically significant differences between the experimental and control groups on any demographic variable. Similarly, there were no differences between the experimental groups for each grade level. Table 3 presents pre-intervention scores on each measure for both groups by grade level. At baseline for kindergarteners and second graders, there were no significant differences between the control and experimental groups on any measure, even before applying the Bonferroni correction. For first-grade students, the control group had statistically significant *higher* pre-intervention scores on MHA size ($M \pm SD = 24.89 \pm 6.63$ for control and $19.92 \pm 8.78$ for experimental; $t = -2.72$, $df = 72$, $p = .0082$) and on THS-Lion ($M \pm SD = 11.20 \pm 3.73$ for control and $9.54 \pm 3.32$ for experimental; $t = -2.03$, $df = 72$, $p = .030$), indicating a better performance by the control group. However, after applying the Bonferroni correction, the differences on neither measure remained statistically significant.

## *Over-Time Differences Within Group and Over-Time Differences Between Groups*

The differences between post- and pre-intervention scores on the THS and MHA are presented for both groups in Table 4. Statistically significant over-time differences are marked with asterisks.

Paired *t* tests showed that kindergarteners in the experimental group had statistically significant increases over time on all three THS subtests (THS-Airplane, THS-Butterfly, THS-Tree). Kindergarteners in the control group, however, also had an increase in scores, but these increases were not statistically significant. Independent samples *t* tests, reported in Table 4, showed that the increases on all three subtests were significantly greater in the experimental group, even after applying a Bonferroni correction for multiple testing.

Paired *t* tests showed that after the intervention, first graders in the experimental group had significant increases on all measures, with the exception of the MHA-Spacing and Legibility measures on which there was no significant change over time, and the MHA-Rate scale, on which there was a significant *decrease*. In contrast, the first graders in the control group had no significant changes on any of the MHA measures but significant increases on four THS subtests: THS-Bus, THS-Frog, THS-Truck, and THS-Book.

**Table 4.** Difference in Differences: Comparing Change Over Time in the Experimental and Control Groups.

| | Change over time (post–pre) | | | | | | Independent samples *t* tests comparing change over time across groups | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Experimental | | | Control | | | | | | | |
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *t* | *df* | *p* value | Adjusted *p* value[a] | \|*d*\|[b] |
| Kindergarten | | | | | | | | | | | |
| THS-Airplane | 27 | 6.6 | 3.2* | 28 | 1.5 | 3.0 | 6.0 | 52.6 | <.0001 | .0000 | 1.6 |
| THS-Butterfly | 27 | 7.2 | 2.3* | 28 | 1.5 | 2.8 | 8.2 | 51.7 | <.0001 | .0000 | 2.2 |
| THS-Tree | 27 | 6.7 | 5.2* | 28 | 2.4 | 4.3 | 3.4 | 50.4 | .0013 | .0388 | 0.9 |
| First grade | | | | | | | | | | | |
| MHA-Rate | 39 | −6.2 | 6.8* | 35 | −0.5 | 5.6 | −4.0 | 71.4 | .0002 | .0051 | 0.9 |
| MHA-Legibility | 39 | 1.3 | 3.6 | 35 | −0.3 | 1.8 | 2.5 | 56.3 | .0143 | .4274 | 0.6 |
| MHA-Form | 39 | 3.8 | 4.9* | 35 | 1.3 | 4.3 | 2.3 | 72.0 | .0249 | .7486 | 0.5 |
| MHA-Alignment | 39 | 7.3 | 7.1* | 35 | 1.2 | 4.3 | 4.6 | 63.3 | <.0001 | .0007 | 1.1 |
| MHA-Size | 39 | 10.7 | 7.6* | 35 | 1.3 | 4.6 | 6.5 | 63.4 | <.0001 | .0000 | 1.5 |
| MHA-Spacing | 39 | 0.6 | 4.6 | 35 | −0.3 | 2.7 | 1.1 | 62.6 | .2979 | 1.0000 | 0.2 |
| THS-Bus | 39 | 4.3 | 3.3* | 35 | 2.1 | 2.7* | 3.3 | 71.2 | .0017 | .0514 | 0.8 |
| THS-Frog | 39 | 4.1 | 2.9* | 35 | 2.0 | 2.3* | 3.6 | 70.0 | .0007 | .0203 | 0.8 |
| THS-Horse | 39 | 4.7 | 4.1* | 35 | 2.4 | 5.0 | 2.2 | 66.4 | .0299 | .8958 | 0.5 |
| THS-Truck | 39 | 4.9 | 4.8* | 35 | 2.7 | 2.7* | 2.5 | 60.9 | .0166 | 0.5037 | 0.6 |
| THS-Book | 39 | 5.1 | 4.4* | 35 | 3.2 | 3.7* | 2.0 | 71.6 | .0505 | 1.0000 | 0.5 |
| THS-Lion | 39 | 6.1 | 3.5* | 35 | 2.3 | 4.1 | 4.3 | 67.8 | <.0001 | .0016 | 1.0 |
| Second grade | | | | | | | | | | | |
| MHA-Rate | 38 | −0.2 | 2.9 | 40 | −0.1 | 3.7 | −0.2 | 73.2 | .8842 | 1.0000 | 0.0 |
| MHA-Legibility | 38 | 0.6 | 2.0 | 40 | −0.9 | 1.9 | 3.1 | 75.4 | .0024 | .0725 | 0.7 |
| MHA-Form | 38 | 2.6 | 4.5* | 40 | −0.8 | 4.6 | 3.3 | 76.0 | .0017 | .0519 | 0.7 |
| MHA-Alignment | 38 | 3.8 | 5.4* | 40 | −1.3 | 3.9 | 4.8 | 66.8 | <.0001 | .0003 | 1.1 |
| MHA-Size | 38 | 11.8 | 8.1* | 40 | −0.3 | 7.8 | 6.7 | 75.4 | <.0001 | .0000 | 1.5 |
| MHA-Spacing | 38 | 0.4 | 2.9 | 40 | −0.9 | 4.2 | 1.6 | 68.7 | .1245 | 1.0000 | 0.4 |
| THS-Airplane | 38 | 3.4 | 3.2* | 40 | 0.3 | 2.2 | 4.9 | 65.3 | <.0001 | .0002 | 1.1 |
| THS-Bus | 38 | 2.5 | 3.3* | 40 | −1.1 | 2.5 | 5.4 | 67.8 | <.0001 | .0000 | 1.2 |
| THS-Butterfly | 38 | 3.6 | 2.8* | 40 | −0.7 | 2.9 | 6.7 | 76.0 | <.0001 | .0000 | 1.5 |
| THS-Frog | 38 | 1.5 | 3.1 | 40 | −1.2 | 2.7 | 3.9 | 73.3 | .0002 | .0061 | 0.9 |
| THS-Tree | 38 | 2.6 | 3.3* | 40 | −0.9 | 3.3 | 4.7 | 75.8 | <.0001 | .0003 | 1.1 |
| THS-Horse | 38 | 3.1 | 4.2* | 40 | −0.9 | 4.3 | 4.1 | 75.9 | <.0001 | .0029 | 0.9 |
| THS-Truck | 38 | 1.5 | 3.0 | 40 | −1.2 | 2.9 | 4.0 | 75.1 | .0002 | .0053 | 0.9 |
| THS-Book | 38 | 1.6 | 3.3 | 40 | −1.7 | 2.5* | 5.0 | 68.1 | <.0001 | .0002 | 1.1 |
| THS-Lion | 38 | 2.8 | 2.6* | 40 | −1.2 | 3.1 | 6.1 | 74.9 | <.0001 | .0000 | 1.4 |

*Note.* Positive means indicate increases in scores over time, whereas negative means indicate decreases in scores. THS = Test of Handwriting Skills; MHA = Minnesota Handwriting Assessment.

[a]Bonferroni-adjusted *p* value, calculated as min{(*unadjusted p value …·number of tests*), 1}. Here, the number of tests is 30.

[b]Cohen's *d* (1988) provided a measure of effect size. Cohen considers $d = 0.2$, $d = 0.5$, and $d = 0.8$ to be small, medium, and large effect sizes, respectively.

*Paired *t* test shows that within-group over-time change is significant: Bonferroni-adjusted *p* value (*p value…number of tests*) $< \alpha = .05$. Here, the number of tests is 60 (30 in experimental group and 30 in control group).

Bonferroni-corrected independent samples *t* tests showed that the experimental group had significantly greater over-time increases on the MHA-Alignment, MHA-Size, THS-Frog, and THS-Lion subtests, and a significantly greater *decrease* on the MHA-Rate measure than the control group.

Second graders in the experimental group had statistically significant over-time increases on most measures (MHA-Form, MHA-Alignment, MHA-Size, THS-Airplane, THS-Bus, THS-Butterfly, THS-Tree, THS-House, and THS-Lion). The control group did not report over-time increases on any measures; there were either significant decreases (e.g., THS-Book subtest) or no change. Bonferroni-corrected independent samples *t* tests showed that the experimental group had significantly greater over-time increases than the control group on MHA-Alignment and MHA-Size and all THS subtests.

## Discussion

This study focused on the effectiveness of an occupational-therapist-developed handwriting program, the SMHP, as a classroom-embedded/curricular-based program to improve

legibility among elementary school children. The results of the study demonstrated that SMHP serves as an effective program for inclusive service delivery to improve handwriting skills. The results identified improved handwriting in the experimental group that, in almost all cases, exceeded those reported by participants in the control group.

Kindergarteners in the experimental group demonstrated substantial improvements over the control group in all areas. First-grade students in the experimental group demonstrated improvement in all of the subtests of the THS-R and MHA with the exception of spacing and rate subtests of the MHA. There were no significant increases in the spacing subtest and a decrease in the rate score. Second graders in the experimental group demonstrated significant improvements in all subtests of both the THS and MHA with the exception of rate, legibility, and spacing subtests of the MHA over time. The control groups demonstrated no over-time changes.

Ceiling effects may explain the lack of improvements in certain subtests of the MHA for first- and second-grade students as both had pre-intervention rate and spacing scores near the maximum. In addition, rate scores only lose points if the test is not completed within 2.5 min. In future studies, it may be better to assess the rate of words/minute to provide a more accurate assessment of speed. Other studies using the MHA as an outcome measure have also reported this finding (Howe, Roston, Sheu, & Hinojosa, 2013; Roberts et al., 2014; Schneck et al., 2012).

Interestingly, rate among first-grade experimental group students statistically decreased over time ($M = -6.18$, $SD = 6.8$, $p < .001$; see Table 4), while the control group showed no changes. Second graders showed no significant rate improvements after intervention. Kindergarteners were not assessed on rate. Several studies provide evidence that when legibility improves, speed declines or shows no improvement (Howe et al., 2013; Mackay et al., 2010; Roberts et al., 2014; Roberts, Siever, & Mair, 2010; Weintraub & Graham, 1998). This phenomenon supports the notion that children need time to produce legible work, and that speed may initially decrease when an emphasis is place on legibility. The teachers in the experimental group confirmed this finding through a qualitative report. They observed that students appeared more deliberate in the post-testing as they wanted to make "Star-Worthy" letters. A longitudinal study assessing speed and legibility may be warranted.

Regardless of site, participants in the experimental groups showed improvement in form, alignment, and size, qualities that contribute to handwriting competence in elementary school students. The experimental groups, in both first and second grades, showed the most improvement in the size subsection of the MHA in comparison with the control group. There were moderate to large effect sizes for all scales that demonstrated significant changes in both tests, with the largest effect sizes calculated for the MHA size subsection. This result was expected as SMHP places a strong emphasis on letter size. This phenomenon of program emphasis may influence results. For instance, HWT stresses form. In one study, examining the effects of HWT, Roberts and colleagues (2014) found significant changes in form. However, this finding was not consistent with other studies where interventions focused on alignment, size, and spacing.

SMHP is a curriculum-embedded intervention. Several previous studies reported findings supporting the use of curricular-based handwriting programs and direct instruction including the Write Start Program (Case-Smith et al., 2011; Case-Smith, Holland, Lane, & White, 2012), the Handwriting Club (Howe et al., 2013), and HWT (Lust & Donica, 2011; Roberts et al., 2014; Wehrmann, Chiu, Reid, & Sinclair, 2006). The findings of the current study provide additional support for inclusive OT practices, as well as an emphasis on explicit and meaningful curriculum-embedded instruction in the provision of OT services to improve handwriting legibility.

A potential benefit of using a program like SMHP is that it is concept-driven. Because of this, it can be implemented in all subjects using vocabulary, spelling words, or other content-related terms from student's current grade-level textbooks. SMHP also uses frequent verbal cues with modeling, identified as important in past handwriting research (Jones & Christiansen, 1999).

Today's schools have limited schedules, budgets, and manpower, but growing needs. Consequently, we must provide programs that are financially responsible and realistic. The crisis facing our schools is itemized by the Center on Budget and Policy Priorities. According to their reports, more than 300,000 teaching positions have been eliminated nationwide, programs have been scaled back and class sizes increased. On the state level, the cost of financing schools barely covers the basics. For handwriting to continue as an essential instruction, it has to easily integrate into curricular content with minimal expenditures.

SMHP needs few materials for implementation. Many are reusable or reproducible. In addition, aides, parents, and peers can implement the program, saving valuable financial resources. With the cost of OT collaboration significantly less than individual instruction, districts can save money while supporting RTI and least restrictive environments. RTI is an emergent trend. It "integrates assessment and intervention within a multilevel preventative system," maximizing student achievement and reducing behavioral problems especially among at-risk students (National Center on Response to Intervention, 2010, p. 2). As RTI mandates evidence-based practices integrated into the curriculum, SMHP can serve as a first-, second-, or top-tier intervention, thereby preventing handwriting issues from negatively affecting other learning outcomes.

Occupational therapists and teachers must use effective and best practices when treating handwriting difficulties. Both RTI and the IDEA require that instruction and interventions are based on peer-reviewed research. Currently, a variety of handwriting programs exist and are widely used by occupational therapists and teachers. While some programs

have shown positive effects on handwriting skills, these findings have not been consistent. What has shown consistency in effecting improvements in handwriting skills is a task-oriented or a multisensory approach, or one with a combination of theoretical underpinnings. In addition, research supports OT collaboration embedded within the classroom. This is especially true when programs include teacher involvement, supplementary materials (e.g., homework), higher-level components such as mnemonics, frequent visual cueing, self-instruction, self-monitoring, and a combination of theories such as sensorimotor, biomechanical, motor learning, and direct instruction. Consistency of instruction links handwriting to functional writing so students have a meaningful connection for learning (Case-Smith et al., 2011). The study not only demonstrates the effectiveness of the SMHP but also reinforces multisensory and task-oriented approaches, curriculum-embedded instruction, and teacher and student empowerment.

There were a number of limitations of the study. First was the inability to randomize individuals to control and treatment groups in both sites. Second, although the control group received comparable time in handwriting instruction, the type of instruction varied between classrooms. Third was the fact that this study did not have a comparison or alternate intervention. It is, therefore, not possible to determine whether SMHP is more effective than other interventions. Next was the exclusion of individuals with specific learning disorders such as dyslexia and developmental motor coordination disorder. These conditions may be more resistant to developing functional handwriting competency due to the nature of the disorder itself. Future research needs to consider other diagnoses.

In summary, this study provides support for the use of the curricular-based SMHP as an effective method of inclusive service delivery to improve handwriting legibility. One of the primary purposes of this study was to establish proof of its effectiveness prior to implementing large-scale studies that measure the impact of handwriting instruction on learning outcomes. Establishing the effectiveness of a curricular-based handwriting program is a necessary foundation and the first step in determining the immediate and longitudinal impact of handwriting legibility. Research has demonstrated links between legibility and written composition, literacy, and reading (James & Gauthier, 2009). It is now essential to identify effective methods that improve handwriting as they relate to specific learning outcomes.

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