

Assessing Handwriting Intervention Effectiveness in Elementary School Students: A Two-Group Controlled Study

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MeSH TERMS

- child
- handwriting
- occupational therapy
- psychomotor performance
- treatment outcome
- visual perception

This study examined the effectiveness of two approaches used in elementary schools to improve children's handwriting. Participants were 72 New York City public school students from the first and second grades. A nonequivalent pretest–posttest group design was used in which students engaged in handwriting activities using two approaches: intensive handwriting practice and visual–perceptual–motor activities. Handwriting speed, legibility, and visual–motor skills were examined after a 12-wk Handwriting Club using multivariate analysis of variance. The results showed that students in the intensive handwriting practice group demonstrated significant improvements in handwriting legibility compared with students in the visual–perceptual–motor activity group. No significant effects in handwriting speed and visual–motor skills were found between the students in intensive handwriting practice group and the students in visual–perceptual–motor activities group. The Handwriting Club model is a natural intervention that fits easily into existing school curriculums and can be an effective short-term intervention (response to intervention Tier II).

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Occupational therapy practitioners working in schools must provide services that are educationally relevant and consistent with the individual school's curriculum and policies. When practitioners provide integrated interventions, they adapt them to be contextually appropriate to meet children's needs. One area of educational relevance is the facilitation of improved handwriting performance for children with poor handwriting.

Occupational therapy practitioners focus on handwriting as a performance skill and often address children's handwriting performance using developmental frameworks. Studies of handwriting remediation provide evidence to support intervention effectiveness despite varying duration, frequency, and method of treatment (Case-Smith, 2002; Denton, Cope, & Moser, 2006; Feder & Majnemer, 2007; Marr, 2005; Marr, Windsor, & Cermak, 2001; Sudsawad, Trombly, Henderson, & Tickle-Degnen, 2001; Volman, van Schendel, & Jongmans, 2006; Woodward & Swinth, 2002). In this study, we adopted two commonly used interventions and provided them within a school club model that we called the Handwriting Club. The interventions used a practice-based approach based on motor learning (Roston, 2010) and a visual–perceptual–motor approach (Beery, Beery, & Evans, 2004a, 2004b). Therapists commonly use both approaches to improve children's handwriting legibility and speed (Feder, Majnemer, & Synnes, 2000).

A practice-based approach based on motor learning is advocated in the literature as a useful strategy in handwriting remediation. Schmidt and Lee (1999) defined *motor learning* as “a set of internal processes associated with practice or experience leading to relatively permanent changes in the capability

for motor skill” (p. 264). Practice, in the motor learning approach, is the most important factor responsible for permanent improvement in the ability to perform a motor skill. If all other factors are held constant, then skill improvement is generally considered to be positively related to the amount of practice, and the practice must occur under varying conditions with contextual interference and different sensory inputs (Guadagnoli & Lee, 2004). In this study, we asked students in the intensive handwriting practice group to perform different types of handwriting tasks under various conditions. We gave them opportunities to practice both low-level (i.e., copying letters and words, handwriting games) and high-level (i.e., text generation) handwriting skills.

Another common method of handwriting remediation is the visual–perceptual–motor approach. The sensory–motor and motor activities used in this approach are based on the frame of reference of developmental vision training (Kaiser, Albaret, & Doudin, 2011; Keogh, 1974). In this approach, visual–motor integration is viewed as an important variable in handwriting performance, particularly when copying or transposing from text to cursive or manuscript writing. Several studies have found visual–motor integration to be one of the most important predictors of handwriting performance, with strong correlations documented between visual–motor integration and writing legibility (Maeland, 1992; Tseng & Murray, 1994; Volman et al., 2006; Weil & Amundson, 1994) or speed of handwriting (Tseng & Chow, 2000). Research (Tseng & Murray, 1994) has shown that children with poor handwriting have poor results on tests such as the Ayres Motor Accuracy test (Ayres, 1989) and the Beery–Buktenica Test of Visual–Motor Integration (VMI; Beery, Buktenica, & Beery, 2004). There was also a positive relationship between VMI assessment scores and students’ ability to copy letter forms legibly (Daly, Kelley, & Krauss, 2003).

Although occupational therapy practitioners routinely address handwriting performance for children with identified disabilities, handwriting difficulties are often not addressed for typically developing children. Creating programs for typically developing children with poor handwriting is consistent with a response to intervention (RtI) paradigm. RtI is an evidence-based initiative that seeks scientific evidence supporting the efficacy of interventions in education and focuses on early support to children (Fuchs & Fuchs, 2006).

Although there is support for the effectiveness of both intensive practice and visual–perceptual–motor interventions, delivering these interventions in the context of a natural school setting in the form of a school club has

not been studied. Thus, in this study we examined two short-term group interventions commonly used by school-based occupational therapy practitioners to improve children’s handwriting speed and legibility. These group interventions were provided in the context of a Handwriting Club, which was consistent with the school’s curriculum and philosophy that included various clubs that children could join. This study had two questions. First, would students’ handwriting legibility and speed improve when they participated in intensive practice and visual–perceptual–motor interventions when provided in a Handwriting Club? Second, which intervention (i.e., intensive practice or visual–perceptual–motor) is more effective in improving students’ handwriting legibility and speed when provided in a Handwriting Club?

Method

Research Design

A nonequivalent pretest–posttest group design was used in which students were assigned alternately to two groups that provided a variety of handwriting activities using two different approaches. To recruit participants, we sent letters to parents and guardians of all first- and second-grade students in one New York City elementary school during the 2007–2010 academic years announcing the Handwriting Club and describing the research. Recruitment letters and consent forms were sent in both English and Spanish. Once we received parents’ or guardians’ consent, we asked children for their assent before testing. Student participants were selected on the basis of their legibility scores on the Minnesota Handwriting Assessment (MHA; Reisman, 1999).

A list with all tested children’s legibility scores from both first and second grade was constructed in a ranking order. Students who had extremely high scores were not invited to participate in the study. We started group assignments with students of medium scores on the list and worked outward in both directions. Students were assigned alternately to two intervention groups. For example, we assigned the first student ranked above medium to Group A and the first student ranked below medium to Group B. We then assigned the student ranked second above medium to Group B and the student ranked second below medium to Group A. The assignment process continued until 8 students had been selected for each group. This assignment method was an attempt to create balanced cohorts for each group. The selection procedure was repeated when each new session of the Handwriting Club began during the data collection years of 2008–2010.

Research procedures were approved by the University Committee on Activities Involving Human Subjects and the New York City Department of Education Proposal Review Committee. All children were given the MHA and the VMI (5th ed.; Beery, Buktenica, & Beery, 2004) before and after their participation in the Handwriting Club.

Instruments

The MHA is a norm-referenced assessment that tests a child's handwriting legibility and speed by asking the child to copy 34 letters in 2.5 min. Reisman (1999) reported good content validity and excellent interrater ($r = .98$) and intrarater ($r = .98$) reliability. In this study, we used a manuscript version and measured handwriting speed on the basis of the total number of letters produced in 2.5 min and handwriting legibility on the basis of the total number of errors in the 34 letters.

The VMI is a norm-referenced, evaluative measure of visual-motor integration for children ages 2–15 yr. The paper-and-pencil assessment has children copy a developmental sequence of geometric forms. Studies have reported that the VMI has acceptable test-retest ($r = .89$), interrater ($r = .92$), and internal ($r = .92$) reliability (Beery, Buktenica, & Beery, 2004) and acceptable construct validity (Brown, Unsworth, & Lyons, 2009).

Intervention

The Handwriting Club met during regular class hours before the end of the school day twice a week for 12 sessions that each lasted 40–45 min. Two occupational therapists with extensive experience working in the school conducted all the group sessions and followed the established protocol (see the Appendix). Neither occupational therapist was blind to group assignment.

Intervention consisted of two approaches commonly used to improve the legibility and speed of children's handwriting. In the club, the children performed different activities depending on their group allocation. Children in the intensive practice group participated in 20 min of their grade-level handwriting curriculum and their grade-level writing tasks. In the intensive practice group, students were encouraged to participate in different levels of handwriting activities, including letter formation and composition.

Because the emphasis of the Handwriting Club was on legibility and speed, mistakes in spelling were not corrected. The children in the visual-perceptual-motor group participated in 20 min of activities from *My Book of Letters and Numbers* and *My Book of Shapes* (Beery et al., 2004a, 2004b). Students from both groups worked with

a commercial handwriting book, *Handwriting Without Tears* (Olsen, 1999), which is part of the school's handwriting curriculum. All sessions ended with handwriting games such as Hangman, Scattergories, Scrutineyes, and Mad Libs.

Data Collection

Karen Laurie Roston and an experienced occupational therapist administered and scored all pretests and posttests. Both therapists were blind to students' identities during the scoring process. Interrater reliability between the two therapists was established with a correlation of .95. Pretest data were collected from all students whose parents had consented to having their child considered for the Handwriting Club. Posttest data were collected only from students who participated in the Handwriting Club.

Data Analysis

Data were analyzed using SAS/STAT Version 9.03 for Windows (SAS Institute Inc., Cary, NC), and the graphics were generated by a package in the statistical software R (Helmreich & Pruzek, 2009). Descriptive and multivariate analyses were conducted for major variables. The level of significance for testing was set at .05. A cluster analysis procedure was used to form homogeneous groups of students with similar characteristics in terms of age, handwriting legibility, speed pretest scores on the MHA, and pretest scores on the VMI. Students were grouped on the basis of the closeness of their combined measure of distance over the four variables. Subsequently, two clusters of each variable were produced on the basis of the students' pretest performance.

In this study, students were not randomly assigned to either intensive practice or visual-perceptual-motor activity groups. Unequal baselines between the two intervention groups of pretest scores in all three dependent variables and of age were inevitable. The cluster analysis provides a way to match key baseline characteristics for within-cluster participants (Johnson, 1967; Michel et al., 2000) to facilitate between-cluster comparisons. The method used to form clusters was agglomerate hierarchical clustering, and the complete-link or furthest-neighbor technique was applied to determine which cases or clusters should be combined at each step (Michel et al., 2000). The complete-link clustering method defines the cluster distance between two clusters to be the maximum distance between their individual elements. A multivariate analysis of variance (MANOVA) was then performed to test the treatment effects between the intensive practice and visual-perceptual-motor activity groups.

Results

A sample of 72 students (38 in the visual–perceptual–motor activity group and 34 in the intensive practice group) participated in this study. We found no significant differences between the two groups in age, pretest score of writing speed on the MHA, or pretest scores on the VMI. Significant differences were found in the pretest score of legibility measured by the MHA ($p = .01$; Table 1). Performance changes in terms of handwriting speed, legibility, and visual–motor skills were examined using MANOVA. The results showed a marginal overall treatment effect, $F(3, 67) = 2.44, p = .07$. Univariate analysis was then performed to examine individual performance. We found significant treatment effects in handwriting legibility, $F(2, 69) = 5.86, p = .018$. That is, students who participated in the intensive practice group demonstrated significant improvements in handwriting legibility compared with students who participated in the visual–perceptual–motor activity group. No significant effects in handwriting speed or in the visual–motor skills measured by the VMI were found between students in the intensive practice group and the visual–perceptual–motor activities group (Table 2).

Figure 1 shows the sizes and direction of the treatment effects of the three outcome variables on assessment. For each plot, circles represent clusters. The size of the circles varies according to the size of the clusters. In our study, Cluster 1 consisted of 65 students and Cluster 2 of only 7 students. Circles positioned below the identity line ($y = x$) indicate that for the corresponding cluster, out-

Table 1. Characteristics of Children and Evidence Using Cluster Analysis on Pretest Data

Characteristic	Group		<i>t</i> Test
	Intensive Practice (<i>n</i> = 34)	Visual–Perceptual–Motor Activity (<i>n</i> = 38)	
Age, yr			.28
Mean	6.69	6.57	
<i>SD</i>	0.42	0.50	
Range	5.93–7.67	5.81–7.93	
Speed, mean ± <i>SD</i>			.44
Pretest	26.88 ± 6.30	25.61 ± 7.46	
Posttest	32.35 ± 3.05	30.79 ± 5.44	
Legibility, mean ± <i>SD</i>			.01**
Pretest	30.56 ± 2.53	27.89 ± 4.84	
Posttest	33.0 ± 1.44	31.97 ± 2.01	
VMI score, mean ± <i>SD</i>			.40
Pretest	58.68 ± 30.78	52.93 ± 26.45	
Posttest	62.44 ± 30.28	52.16 ± 26.33	

Note. Speed and legibility were measured using the Minnesota Handwriting Assessment. *SD* = standard deviation; VMI = Beery–Buktenica Test of Visual–Motor Integration.

** $p < .01$.

Table 2. Multivariate and Univariate Analyses of Variance *F* Ratios for Handwriting Measurement

Multivariate		Univariate					
		Legibility		Rate		VMI	
<i>F</i> ^a	<i>p</i>	<i>F</i> ^b	<i>p</i>	<i>F</i> ^b	<i>p</i>	<i>F</i> ^b	<i>p</i>
2.44	.072	5.86	.018*	2.02	.16	2.52	.117

Note. Multivariate *F* ratio was generated from Pillai's statistic. VMI = Beery–Buktenica Test of Visual–Motor Integration.

^aMultivariate *df* = 3, 67. ^bUnivariate *df* = 2, 69.

* $p < .05$.

come means are larger than the means of the control group (visual–perceptual–motor activity group). This is true for all outcome variables except the posttest speed of Cluster 2 (Figure 1B). In other words, mean scores on handwriting posttest legibility and speed, as well as mean scores on the posttest VMI, in the intensive practice group were better than those of the visual–perceptual–motor group except for the posttest speed of Cluster 2, echoing the results presented in Table 1.

Discussion

This study compared the short-term effectiveness of two interventions designed to improve children's handwriting performance. Results indicate that the students exposed to traditional handwriting instruction that included intensive practice and repetition produced handwriting scores that were significantly better in legibility than the students exposed to visual–perceptual–motor activities. This finding echoes those of most studies of handwriting intervention, which have reported an improvement in the legibility of children's handwriting but no significant changes in speed (Feder & Majnemer, 2007; Jongmans, Linthorst-Bakker, Westenberg, & Smits-Engelsman, 2003).

In this study, we did not find significant intervention effects in handwriting speed between students in the intensive practice group and those in the visual–perceptual–motor activities group. We cannot draw conclusions about handwriting speed because of the limitations of the MHA. A large percentage of the students in both groups (65.8% visual–perceptual–motor activity group, 73.5% intensive practice group) completed the test within the time limit after intervention. In accordance with MHA scoring, students began to lose points for rate only if they did not complete the test within 2.5 min. A student who took 1 min to complete the test received the same rate score as a student who took 2 min. Differences in speed between these students were therefore difficult to assess. Rather than setting a predetermined time limit, future studies should look for group differences in average completion time. In addition, although the readability

of a handwriting sample seems to be considered more important than speed, one should not ignore the contribution of handwriting speed, especially for students who perform higher-order skills such as composition. Graham, Berninger, Abbott, Abbott, and Whitaker (1997) reported that handwriting speed accounted for a significant proportion of the variability in children's compositions.

Our study demonstrated no significant differences in students' visual-motor integration skills after intervention. Previous studies reported that visual-motor integration contributes significantly to quality (Maeland, 1992; Volman et al., 2006; Weintraub & Graham, 2000) or speed (Tseng & Chow, 2000) of handwriting only in children with motor problems, such as children with developmental coordination disorder or children with handwriting difficulties. No significant changes in visual-motor integration skills after intervention were expected because students in our study were all recruited from mainstream classes.

The use of visual-motor integration skills as a predictor of handwriting performance continues to be debated because the underlying mechanisms responsible for handwriting difficulties are not yet understood (Feder & Majnemer, 2007; Volman et al., 2006). Goyen and Duff (2005) examined the ability of the VMI to discriminate between children with and without handwriting dysfunction. They found that the VMI correctly identified only a small number of the children with handwriting dysfunction (sensitivity = 34%). They concluded that although the VMI provides reliable and valid information regarding visual-motor deficits, which may contribute to poor handwriting, the VMI should be used with caution as a screening tool for children with poor handwriting (Feder & Majnemer, 2007; Goyen & Duff, 2005; Overvelde & Hulstijn, 2011). Consequently, the VMI may have limitations in measuring the effectiveness of intervention.

In this study, MANOVA was used to detect the effects of intervention. Despite the fact that we found no general effect in MANOVA when we considered multiple variables including age, speed, and legibility together, we were

direction of outcome. (B) The two clusters are in the opposite direction of outcome.

Note. Although the effect direction of Cluster 2 is different, it reflects only 7 students. The circles represent clusters, the heavy dotted line indicates overall adjusted outcome, and the dashed lines indicate weighted means for the control and treatment groups, respectively. The centers of circles are projected parallel to the identity line to the lower left line segment, where the crosses show the distribution of cluster differences; the heavy dotted line corresponds to the mean of this distribution of differences. The heavy line segments perpendicular to the identity line are 95% confidence intervals for the estimator population treatment effect.

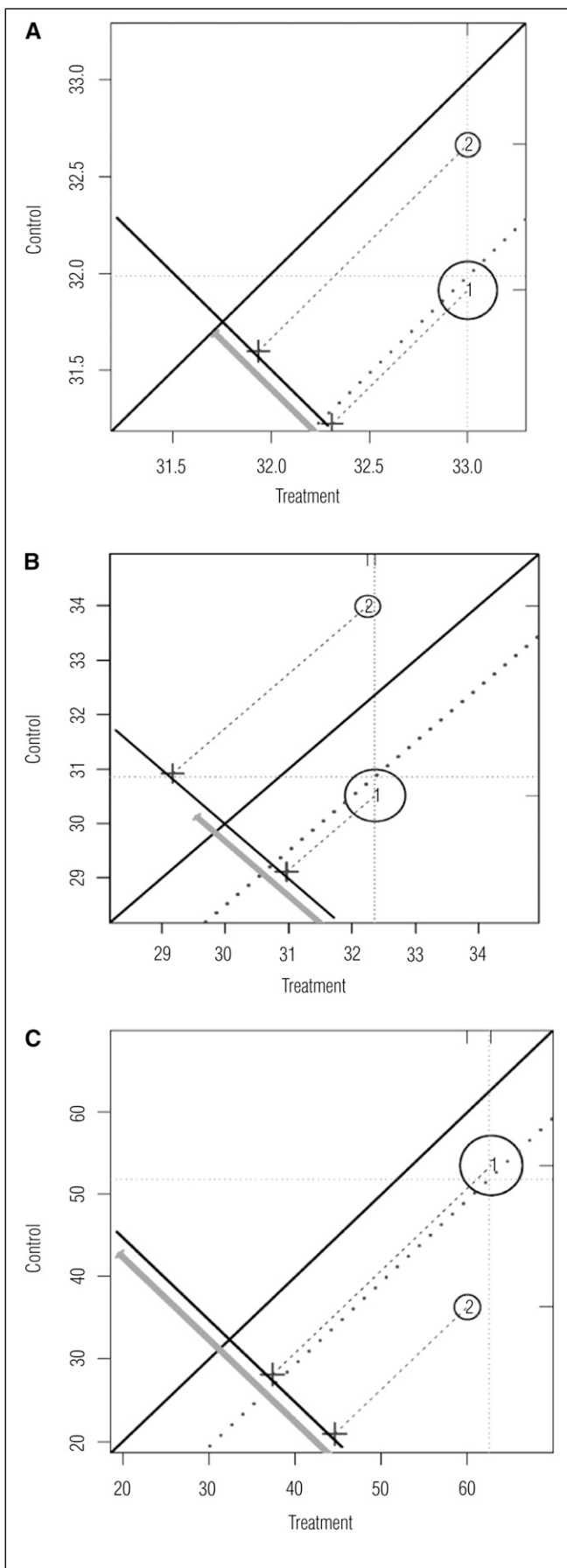


Figure 1. Assessment plot of (A) posttest legibility, (B) posttest speed, and (C) posttest scores on the Beery-Buktenica Test of Visual-Motor Integration. (A) Both clusters are uniform in the

able to demonstrate that students who participated in the intensive practice group had significantly better scores in legibility than students who were in the visual–perceptual–motor activity group in univariate analysis. The possible reason for the lack of overall effect in multivariate analysis is that students' performances on writing speed and legibility were not normally distributed in our sample. Therefore, the data distribution might not support the multivariate analysis. Specifically, the distributions of MHA scores collected in this study were all shifted upward. That is, most of the students tended to have higher scores in both the speed and the legibility categories.

One of the drawbacks of observational study is the inability to control the participants' group assignments to achieve balanced covariance between the two groups prior to interventions. In this study, scores on handwriting speed between the two groups differed significantly before intervention. This unbalanced baseline between treatment and comparison groups is most likely inherited when randomized controlled design is not observed (Cousens et al., 2011). Consequently, generating a confounded effect estimate (one that mixes the effects of the intervention with other causal effects) is a risk of such a study.

The cluster analyses used in this study served to control confounding variables by putting students with similar attributes into one group before the comparison analyses. In the study, two clusters were formed after cluster analyses. Seven students were separated from the majority of students to form the second cluster. A close examination of the students in this cluster found that 5 of the 7 were later identified as students with individualized education programs (IEPs), and 2 had significantly higher performance scores. This finding explains why this cluster behaved differently from Cluster 1, which contained the majority of students (see Figure 1).

Limitations and Directions for Further Research

The major limitations of this study are the lack of randomization when assigning participants to the groups, lack of blinding to group assignment of occupational therapists conducting the groups, small sample size, and the ceiling effect of the MHA. In addition, internal validity is limited by possible coincidental events that may have occurred in the school such as an increased interest in handwriting by teachers because of the initiation of the Handwriting Club. The possibility also existed of bias by the primary researcher in the scoring of the MHA and VMI. This bias

was mediated by independent scoring of the MHA and VMI by another senior occupational therapist.

Falk, Tam, Schellnus, and Chau (2011) proposed a computer-based handwriting assessment tool to objectively quantify handwriting proficiency in children. They combined the MHA with an instrumental utensil and digitizing tablet to assess children's handwriting performance. This computer-based handwriting assessment tool measures essential biomechanical quantities such as grip force, vertical pressures, and timing during writing, in addition to the five categories that the MHA traditionally assesses (legibility, form, alignment, size, and space). We believe that this newly developed tool offers an innovative dimension to research on handwriting components. Moreover, high-level handwriting skills such as composition should also be considered as an outcome variable for future studies (Case-Smith, Holland, & Bishop, 2011).

Implications for Occupational Therapy Practice

Researchers in handwriting instruction have continued to recommend a direct and structured approach (Jongmans et al., 2003), which is supported by the current study. Occupational therapy practitioners should consider the following implications of this study:

- Repetition and practice are important elements enhancing children's handwriting skills.
- The work of school-based occupational therapists should be entwined with the school curriculum.
- The Handwriting Club model is a natural intervention that fits easily into existing school curriculums. It allows the students to intensively practice handwriting with a variety of tasks that are embedded in the curriculum based on motor learning principles. Additionally, student participants enjoyed participating and demonstrated improved legibility.

Conclusion

In this study, both groups showed improvement in handwriting legibility. However, students in the intensive practice group improved significantly more than students in the visual–perceptual–motor activity group. This study is important to practice because it evaluates the results of a short-term RtI Tier II intervention model for providing occupational therapy services in the school environment for at-risk students, for students with IEPs, and for children with handwriting difficulties as identified by their parents. Students in the handwriting group reported enjoying practicing their handwriting and demonstrated

pride in the completion of their final product. Parents and teachers were also impressed that their children's handwriting improved. One parent commented, "Before the Club, I could never read my child's handwriting. Now I can!" (parent communication, April 2010). ▲

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Appendix: Handwriting Club Group Format

Activity Category and Time Frame	Intensive Practice Group Activities	Visual-Perceptual-Motor Activity Group Activities
Setup	Sign in on the attendance sheet.	Sign in on the attendance sheet.
Activities designed by therapists using different approaches: 20 min	<p>Answer question of the day in their best handwriting in their journals.</p> <p>Work in handwriting book with a variety of pencils and pencil grips.</p> <ul style="list-style-type: none"> • Select pencils. • Try on pencil grips. <p>Engage in sharing and feedback.</p> <ul style="list-style-type: none"> • When a page is finished, circle the three most legible words. • Trade page with another student. • Circle the most legible word on each other's pages. 	<p>Work on visual-perceptual worksheets.</p> <ul style="list-style-type: none"> • Select from a variety of colored pencils or markers of different diameters.
Handwriting activities for both groups: 15 min	<p>Work in commercial handwriting book <i>Handwriting Without Tears</i>.</p> <p>Receive instruction (e.g., letter models with arrows, demonstration of letter formation).</p> <p>Text generation: Practice higher-level handwriting skills.</p> <ul style="list-style-type: none"> • Letter writing (e.g., write letters to teachers, classmates, parents, or principal on own choice of topic) • Recipe contest (e.g., write down favorite snacks and a recipe for how to make them) 	<p>Work in commercial handwriting book <i>Handwriting Without Tears</i>.</p> <ul style="list-style-type: none"> • Select pencils. • Try on pencil grips. <p>Engage in sharing and feedback.</p> <ul style="list-style-type: none"> • When a page is finished, circle the three most legible words. • Trade page with another student. • Circle the most legible word on each other's pages.
Handwriting game: 10 min	Hangman, Scattergories, Scrutineyes, Mad Libs, or other games that use handwriting on a vertical whiteboard	Hangman, Scattergories, Scrutineyes, Mad Libs, or other games that use handwriting on a vertical whiteboard
Closure	Clean up and go home	Clean up and go home

Note. The club met at the end of the school day twice a week for 12 sessions that lasted 40–45 min each.