

Supplemental Table 1. Summary of the Evidence Examining the Effectiveness of Curriculum-Based Handwriting Programs

Author/Year	Objectives	Level of Evidence/Study Design/ Participants/Inclusion Criteria	Intervention and Control Groups	Intervention Length	Outcome Measures	Results
Case-Smith, Holland, & Bishop (2011) https://doi.org/10.5014/ajot.2011.000984	To develop and pilot test Write Start, an integrated handwriting and writing program for 1 st grade students	Level III Single group pretest-posttest <i>N</i> = 19 1 st grade students (11 boys, 8 girls; <i>M</i> age = 77.5 mo; age range = 68-86 mo); 2 received special edu; 1 received OT and speech; 1 in RtI program	<i>Intervention</i> Modeling and copying of letter formation, small group station teaching, embedded individualized support, guiding, monitoring, and providing feedback Co-taught by 2 teachers and OT	2 45-min sessions/wk for 12 wks (18hr)	ETCH-M and MHA to assess legibility and speed WJIII Writing Fluency and Writing Samples Test to assess writing performance	Significant improvements in legibility, speed, and fluency Maintained at 6-mo follow-up
Case-Smith, Holland, Lane, & White (2012) https://doi.org/10.5014/ajot.2012.004333	To examine the effects of Write Start for 1 st grade students grouped by low, avg, and high baseline legibility	Level III Single group pretest-posttest <i>N</i> = 36 1 st grade students (21 boys, 18 girls; <i>M</i> age = 77.4 mo; age range = 72-88 mo) with cognitive level >70% on academic testing; 6 students with IEPs <i>Inclusion Criteria</i> Classrooms with ≥2 students with IEPs and willing teacher	<i>Intervention</i> Station teaching with high- and low-performing students in each group, multisensory activities for learning letter formation, sentence and story writing, peer modeling and feedback, frequent teacher/OT feedback, and self-evaluation Co-taught by classroom teacher, intervention specialist, and OT	2 45-min sessions/wk for 12 wks (18hr)	ETCH-M to assess legibility and speed WJIII Writing Fluency and Writing Samples Test to assess writing performance	Significant improvements in legibility, speed, and fluency; low-performing students improved most in legibility Maintained at 6-mo follow-up
Case-Smith, Holland, & White (2014) https://doi.org/10.3109/01942638.2013.783898	To compare Write Start with a standard handwriting program	Level II Nonrandomized comparison group <i>N</i> = 67 1 st grade students; 7 students with IEPs Intervention group, <i>n</i> = 37 (19 boys 18 girls; <i>M</i> age = 77.3 mo; age range = 72-88 mo) Control group, <i>n</i> = 30 (14 boys, 16 girls; <i>M</i> age = 79.0 mo; age range = 65-92 mo) <i>Inclusion Criteria</i> Children without visual impairment or cognitive disabilities. English as first language.	<i>Intervention</i> Write Start curriculum; station teaching, modeling and copying of letter formation, frequent teacher/OT feedback and monitoring, peer modeling and feedback Co-taught by 2 teachers and OT <i>Control</i> Standard instruction; classroom teachers provided 20 min of handwriting and 20 min of writing instruction 4 days/wk	2 45-min sessions/wk for 12 wks (18hr)	ETCH-M to assess legibility and speed WJIII Writing Fluency and Writing Samples Test to assess writing performance	Significant improvements in lowercase alphabet legibility and writing fluency in Write Start group compared to control group No significant difference in speed, avg legibility, and written expression between groups

(Continued)

Supplemental Table 1. Summary of the Evidence Examining the Effectiveness of Curriculum-Based Handwriting Programs (cont.)

Author/Year	Objectives	Level of Evidence/Study Design/ Participants/Inclusion Criteria	Intervention and Control Groups	Intervention Length	Outcome Measures	Results
Case-Smith, Weaver, & Holland (2014) https://doi.org/10.5014/ajot.2014.011585	To examine the effects of Write Start for 1 st grade students and determine if the program benefits students with diverse learning needs	Level II Nonrandomized comparison group <i>N</i> = 135 1 st grade students Intervention group, <i>n</i> = 77 Control group, <i>n</i> = 55 <i>Inclusion Criteria</i> Students in 1 st grade regular education classrooms. English as first language.	<i>Intervention</i> Write Start curriculum; station teaching, modeling and copying of letter formation, frequent teacher/OT feedback, peer modeling and feedback Co-taught by 2 teachers and OT <i>Control</i> Standard instruction following district's writing curriculum; 15-20 min sessions 3-4 days per wk	2 45-min sessions/wk for 12 wks (18hr)	ETCH-M to assess lowercase legibility and speed WJIII Writing Fluency and Writing Samples tests to assess writing fluency and writing composition	Significant improvements in legibility and speed in Write Start group compared to control group No improvement in writing fluency at posttest, but fluency significantly higher in Write Start group at 6-mo follow-up Write Start students with low baseline legibility made significant improvements
Donica (2015) https://doi.org/10.5014/ajot.2015.018366	To determine the effectiveness of the HWT kindergarten printing curriculum	Level II Two-group non-randomized controlled trial <i>N</i> = 59 half-day kgrtn students in private school Intervention group, <i>n</i> = 40 (23 boys, 17 girls; <i>M age</i> = 76.05 mo) Control group, <i>n</i> = 19 (16 boys, 3 girls; <i>M age</i> = 77.68 mo)	<i>Intervention</i> Kgrtn HWT lessons; gross motor activity with handwriting-related song, learning activity (forming letters with multisensory manipulatives or workbook writing) Taught by classroom teachers; OT/OT students present for one lesson per wk <i>Control</i> Teacher-developed instruction using D'Nealian style of writing	15 min/day over 2 yr (~90hr)	THS-R manuscript assessment to assess legibility	Significant improvements in legibility in HWT group compared to control group
Donica, Goins, & Wagner (2013) https://dx.doi.org/10.1080/19411243.2013.810938	To determine the effects of two different handwriting readiness programs	Level II Three group non-randomized controlled trial <i>N</i> = 48 Head Start students Intervention group A, <i>n</i> = 16 (4 boys, 12 girls; <i>M age</i> = 57.2 mo) Intervention group B, <i>n</i> = 18 (11 boys, 7 girls; <i>M age</i> = 50.7 mo) Control group, <i>n</i> = 14 (8 boys, 6 girls; <i>M age</i> = 48.7 mo) <i>Inclusion Criterion</i> Teacher interest	<i>Intervention</i> Implemented during classroom center time by 2 graduate assistants <i>Group A</i> The Fine Motor and Early Writing Pre-K curriculum; station teaching with adapted writing tools, workbooks, and sensory activities <i>Group B</i> HWT-GSS curriculum; music and movement, station teaching with multi-sensory tools to learn body awareness and fine-motor skills <i>Control</i> No additional handwriting instruction provided	10-15 min (during 1hr center time) 2X/wk for 16 wks (~6.67hr)	SHS to assess pre-writing skills and letter/number formation	No significant changes in legibility in the intervention groups compared to the control group

(Continued)

Supplemental Table 1. Summary of the Evidence Examining the Effectiveness of Curriculum-Based Handwriting Programs (cont.)

Author/Year	Objectives	Level of Evidence/Study Design/ Participants/Inclusion Criteria	Intervention and Control Groups	Intervention Length	Outcome Measures	Results
Howe, Roston, Sheu, & Hinojosa (2013) https://doi.org/10.5014/ajot.2013.005470	To examine the effectiveness of an intensive handwriting practice (IP) compared to visual-perceptual-motor (VPM) activities provided in a Handwriting Club	Level II Two group non-randomized controlled trial <i>N</i> = 72 1 st and 2 nd grade students Intervention group A, <i>n</i> = 38 (<i>M</i> age = 6.57yr; age range = 5.81-7.93yr) Intervention group B, <i>n</i> = 34 (<i>M</i> age = 6.69yr; age range = 5.93-7.67yr) <i>Inclusion Criteria</i> No students with extremely high scores on the MHA pre-intervention	<i>Intervention</i> Handwriting Clubs led by OTs <i>Group A</i> IP; motor learning techniques, grade-level handwriting curriculum and writing tasks, focus on letter formation and composition, HWT book, handwriting games <i>Group B</i> VPM; activities from letters/number/shapes book, HWT book, handwriting games	40-45 min 2X/wk for 6 wks (~8.5hr)	MHA to assess speed and legibility	Significant improvements in legibility but not speed in IP group compared to VPM group
Kaiser, Albaret, & Doudin (2011) https://doi.org/10.2466/11.25.PMS.112.2.610-618	To investigate the effects of an explicit handwriting program for 1st grade students	Level II Two-group nonrandomized controlled trial <i>N</i> = 42 1 st grade students Intervention group, <i>n</i> = 23 (8 boys, 15 girls; age range = 6.1-7.3yr) Control group, <i>n</i> = 19 (8 boys, 11 girls) <i>Inclusion Criteria</i> Enrollment in a school in rural Switzerland.	<i>Intervention</i> Explicit handwriting program; digital dexterity exercises, discussion about usefulness of handwriting, teaching of letters in cursive only, practice, metacognitive task Administered by author and 2 OT students <i>Control</i> 40 min/wk, practiced 2-3 letters by copying individual letters and words containing the letters	45 min 2X/wk for 6 wks (9hr)	French version of the BHK-Concise Assessment Scale for Children's Handwriting to assess handwriting speed and quality	Significant improvements in post-test legibility and speed in explicit handwriting group compared to control group
Lust & Donica (2011) https://doi.org/10.5014/ajot.2011.000612	To measure handwriting readiness and fine motor skills of preschool students in HWT-GSS program	Level II Two-group nonrandomized controlled trial <i>N</i> = 32 preschool students Intervention group, <i>n</i> = 17 (8 boys, 9 girls; <i>M</i> age = 55.4mo) Control group, <i>n</i> = 15 (10 boys, 5 girls; <i>M</i> age = 55.9mo) <i>Inclusion Criteria</i> Classrooms selected by Head Start director and children had no identified cognitive or physical deficit that would affect fine motor skills	<i>Intervention</i> HWT-GSS in addition to Head Start curriculums; small group activities for body awareness, directional concepts, letter-play, coloring, tracing capital letters and shapes Led by Head Start teacher and OT/OT students with training in HWT-GSS curriculum <i>Control</i> Head Start curriculum	3 20-min sessions/wk for 5 mo (47 total) (~15.67hr)	LAP-3 Pre-Writing domain to measure child skill development Check Readiness tool to measure kindergarten readiness skills	Significant improvements in kindergarten readiness and children's skill development in HWT-GSS group compared to control group

(Continued)

Supplemental Table 1. Summary of the Evidence Examining the Effectiveness of Curriculum-Based Handwriting Programs (cont.)

Author/Year	Objectives	Level of Evidence/Study Design/Participants/Inclusion Criteria	Intervention and Control Groups	Intervention Length	Outcome Measures	Results
Pfeiffer, Rai, Murray, Brusilovskiy (2015) https://doi.org/10.1177/1539449215573004	To study changes in handwriting legibility among kgrtn-2 nd grade students receiving the Size Matters Handwriting Program (SMHP)	Level II Two-group pre-post-test (one school had randomized classrooms, while the other did not) N = 207 students (age range = 5-8yr); 55 kgrtn (23 boys, 32 girls), 74 1st grade (31 boys, 43 girls), 78 2nd grade (33 boys, 45 girls); 9 students with an IEP; 18 students with a diagnosis; 19 students receiving OT services	<i>Intervention</i> SMHP; focus on letter size (instruction varied based on grade level); direct instruction, memorable mnemonics, motivational incentives, visual cueing, self-critique and monitoring Taught by classroom teacher; OTs onsite to provide support <i>Control</i> Standard instruction implemented by classroom teacher; varied between classes and schools	40 20-min sessions (~13.33hr)	THS-R to assess manuscript legibility (specific subtests varied based on grade level) MHA to assess speed, rate, legibility, form, alignment, size, and spacing	Significant improvements in legibility in the SMHP group compared to control group Speed decreased more in SMHP group compared to control group
Roberts, Derkach-Ferguson, Siever, & Rose (2014) https://doi.org/10.1177/0008417414527065	To examine the effectiveness of HWT program on the handwriting skills of 1 st grade students	Level II Quasi-experimental cross-over design N = 149 1 st grade students (M age = 6.2) Group A, n = 77 (40 boys, 37 girls) Group B, n = 72 (43 boys, 29 girls) <i>Inclusion Criteria</i> School had to have ≥2 1 st grade non-special education classes in English. Teachers and administrators had to agree to participate and commit to the HWT program	Group A and Group B switched after one 9-wk block so each received intervention and control <i>Intervention</i> HWT instruction using HWT kindergarten workbook and multisensory materials Teacher led; OT supported teacher but did not implement intervention <i>Teacher-designed instruction group</i> Methods chosen by the teacher, could not include HWT techniques or materials	5 20-min sessions/wk for 9 wks; 9-wk blocks/yr for 2 yrs (15hr)	MHA to assess legibility and speed	Significant improvements in form, spacing, alignment, and size in HWT group compared to control group No significant improvements in legibility or speed in HWT group compared to control group
Salls, Benson, Hansen, Cole, & Pielielek (2013) https://doi.org/10.1080/19411243.2013.810958	To compare the results of 2 handwriting curricula on handwriting performance in 1st grade students	Level II/III Two-group repeated measures design, but no control group N = 31 1 st grade students (age range = 6 yr 0 mo-7yr 1 mo) Intervention Group A, n = 14 (6 boys, 8 girls; M age = 6.5yr) Intervention Group B, n = 17 (11 boys, 6 girls; M age = 6.6yr) <i>Inclusion Criteria</i> Students could not be receiving special education or OT services	<i>Intervention</i> Implemented by teachers with specific training in curriculums <i>Group A</i> HWT; sensorimotor activities for learning letter formation <i>Group B</i> Peterson Directed Handwriting Method; focus on movement sequence and rhythm	School year (hr unknown)	The Print Tool to assess memory, orientation, placement, size, start, sequence, control, and spacing MHA to evaluate legibility, form, alignment, size, and spacing	Within group improvements in speed but not legibility No significant differences in improvements between groups

(Continued)

Supplemental Table 1. Summary of the Evidence Examining the Effectiveness of Curriculum-Based Handwriting Programs (cont.)

Author/Year	Objectives	Level of Evidence/Study Design/ Participants/Inclusion Criteria	Intervention and Control Groups	Intervention Length	Outcome Measures	Results
Taras, Brennan, Gilbert, & Eck Reed (2011) https://doi.org/10.1080/19411243.2011.62955	To evaluate the effectiveness of the Write Direction handwriting program for kgrtn students	Level II Pre-test post-test matched comparison group $N = 382$ kgrtn students Intervention group, $n = 211$ Control group, $n = 171$	<i>Intervention</i> Write Direction curriculum; warm-up and directionality exercises, target letters of the day, and letter formation practice <i>Control</i> Teachers taught handwriting using their preferred teaching methods	30-min sessions for 14 wks (7hr)	Routine district-level functional measurement tool to assess legibility, formation, directionality, and proportion of letters	No significant improvements in legibility for Write Direction group compared to control group Significant improvements in letter skills

Note. avg = average; edu = education; ETCH-M = Evaluation Tool of Children's Handwriting-Manuscript; HWT = Handwriting Without Tears; HWT-GSS = Handwriting Without Tears Get Set for School; IEP = Individualized Education Program; IP = Intensive practice; kgrtn = kindergarten; LAP-3 = Language Accomplishment Profile; MHA = Minnesota Handwriting Assessment; min = minute/s; mo = month(s); OT = occupational therapist/occupational therapy; RTI = response-to-intervention; SHS = The Shore Handwriting Screening for Early Handwriting Development; SMHP = Size Matters Handwriting Program; THS = Test of Handwriting Skills; THS-R = Test of Handwriting Skills-Revised; VPM = visual-perceptual-motor; WJIII = Woodcock-Johnson III Tests of Achievement; wk/wks = week(s); yr/s = year/s.

Supplemental Table 2. Risk-of-Bias Table

Citation	Selection Bias		Performance Bias		Detection Bias		Attrition Bias		Reporting Bias
	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment: Self-Reported Outcomes	Blinding of Outcome Assessment: Objective Outcomes	Incomplete Outcome Data	Selective Reporting		
Case-Smith, Holland, & Bishop (2011) https://doi.org/10.5014/ajot.2011.000984	NA	NA	NA	NA	+	+	+	+	
Case-Smith, Holland, Lane, & White (2012) https://doi.org/10.5014/ajot.2012.004333	NA	NA	?	NA	+	+	+	+	
Case-Smith, Holland, & White (2012) https://doi.org/10.3109/01942638.2013.783898	NA	NA	?	NA	+/-	+	+	+	
Case-Smith, Weaver, & Holland (2014) https://doi.org/10.5014/ajot.2014.011585	NA	-	?	NA	+	+	+	+	
Donica (2015) https://doi.org/10.5014/ajot.2015.018366	NA	-	-	NA	-	?	?	+	
Donica, Goins, & Wagner (2013) https://dx.doi.org/10.1080/19411243.2013.810938	NA	-	-	NA	-	+	+	+	
Howe, Roston, Sheu, & Hinojosa (2013) https://doi.org/10.5014/ajot.2013.005470	NA	+	?	NA	+/-	?	?	+	
Kaiser, Albaret, & Doudin (2011) https://doi.org/10.2466/11.25.PMS.112.2.610-618	NA	?	?	NA	?	?	?	?	
Lust & Donica (2011) https://doi.org/10.5014/ajot.2011.000612	NA	-	-	NA	-	+/-	+	+	
Pfeiffer, Rai, Murray, & Brusilovskiy (2015) https://doi.org/10.1177/1539449215573004	NA	?	?	NA	?	+	+	+	
Roberts, Derkach, Ferguson, Siever, & Rose (2014) https://doi.org/10.1177/0008417414527065	NA	NA	NA	NA	+	+	+	+	

(Continued)

Supplemental Table 2. Risk-of-Bias Table (cont.)

Citation	Selection Bias		Performance Bias Blinding of Participants and Personnel	Detection Bias		Attrition Bias Incomplete Outcome Data	Reporting Bias Selective Reporting
	Random Sequence Generation	Allocation Concealment		Blinding of Outcome Assessment: Self-Reported Outcomes	Blinding of Outcome Assessment: Objective Outcomes		
Salls, Benson, Hansen, Cole, & Piellelele (2013) https://doi.org/10.1080/19411243.2013.810958	NA	-	?	NA	+	?	+
Taras, Brennan, Gilbert, & Eck Reed (2011) https://doi.org/10.1080/19411243.2011.62955	NA	-	?	NA	?	?	+

Note. Categories for risk of bias: + = low risk of bias; +/- = moderate risk of bias; - = high risk of bias; ? = insufficient information. 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.