

MATRIX

<i>Reference</i>	<i>Purpose Question</i>	<i>Population and Design</i>	<i>Level of Evidence</i>	<i>Intervention</i>	<i>Outcome Measures & Results</i>	<i>Conclusions Recommendations/Limitations</i>
Beringer, Vaughan, Abbott, Abbot, Rogan, Brooks, Reed. & Graham, (1997)	-To determine if process oriented handwriting instruction was the best predictor of achievement. -To determine the effectiveness of various instructional interventions	N=144 first graders, assigned to 1 of 6 groups, 5 treatment conditions plus one control. Students were from 11 different public and private schools. Evaluators were blind to group assignments. Tutors received substantial training. Pre-test/posttest design. Random. Control group.	Level 2	Intervention was delivered to groups of 3 that met 2X/wk for 20 minutes until they completed 24 lessons. Five groups received 10 minutes of different kinds of handwriting instruction Group 1- motoric imitation (teacher modeling, nonverbal cues) Group 2 – visual cues (numbered arrows on starting points and directionality) Group 3 – Memory retrieval (No visual model) Group 4 – Visual cues and memory Group 5 – Copying, no cuing Group 6 (Control) – 10 minutes of phonological awareness	Outcomes measured were Criterion Referenced and included quality of writing based on tutor observations and videotapes of children’s’ performance using same copying tasks as in pretest administered in individual and group settings. - Treatment associated with the best performance was visual cues plus memory retrieval - Treatment as a whole was more effective than no treatment. - Treatment was inconsistent in improving quality.	CONCLUSIONS: Combining numbered arrow and memory retrieval was the most effective treatment for improving handwriting. Frequent, explicit handwriting instruction within a process approach benefits handwriting fluency. LIMITATIONS: - Automaticity of writing was not discussed - This study combined some elements, but not all. - Statistical analysis not available for review. RECOMMENDATIONS: Frequent, brief, explicit handwriting instructions should be employed.
Berninger, V. W., Rutberg, J. E., Abbott, R. D., Garcia, N., Anderson-Youngstrom, M., Brooks, A. & Fulton, C. (2006)	Study 1- To evaluate whether direct instruction in motor and orthographic skills is more effective than direct instruction alone. Study 2- To evaluate whether motor training or orthographic training added	Study 1, N=14 first grade children, randomly assigned to one of two treatment groups. Pretest-posttest design. Study 2, N=20, Mean age 6 yrs.	Level 2 Level 2	Study 1- Ten individual treatment sessions. Neurodevelopmental group received 5 orthographic-free motor activities (e.g. activities for hand strengthening, finger kinesthetic, eye-hand coordination, dexterity and motor planning) and motor-free orthographic activities (e.g. visual memory and coding games) followed	Study 1 Outcomes measured were Criterion Referenced and included letter accuracy, alphabet writing and writing speed. - Combined neurodevelopmental and handwriting instruction resulted in faster individual growth and appeared related to increased accuracy and legibility. - Handwriting instruction	CONCLUSIONS: Study 1 Neurodevelopmental training (orthographic-free motor activities and motor-free orthographic activities) led to improved accuracy and legibility of letter formation, but direct handwriting instruction with visual cues and verbal mediation led to improved automaticity, speed and composition. In study 2 Neither motor training or orthographic training improved upon direct instruction though both contributed to

	advantage beyond training in letter writing alone.	5 mo. Children were randomly assigned to either motor training and writing group of orthographic coding and writing group. Pretest-posttest.		by 5 direct handwriting instruction sessions. Other treatment group only received handwriting instruction. Direct instruction included only visual and verbal modeling and copying. Study 2- Motor + Write treatment group practiced tracing and copying with directional arrows and mind's eye imagery from 12 handwriting lessons. Ortho + Write group practiced visual memory of letters in a keyboard game.	alone was more effective in promoting automaticity and speed Study 2 Outcomes measured were Criterion Referenced and included time needed to complete a paper-pencil task. - use of pencil to practice letter formations improved speed of grapho-motor planning more than activities that practiced naming letter forms. - Marginally significant difference for writing letters legibly and quickly when practiced.	handwriting legibility. LIMITATIONS: - No control group. RECOMMENDATIONS: Research the impact of verbal cueing for self-regulation when initially learning the letters versus more visual cuing once letter recognition is in place.
Burton, & Dancisak, (2000)	-To examine the effect of grip form and diameter of grip form on drawing accuracy	N=60 Children 3, 4 and 5 years. Comparative study, not random assignments.	Level 3	Intervention involved 20 trials with a precision drawing task and 4 trials each with 5 writing implements of different diameters. Children completed a drawing task.	Outcomes measured were Criterion Referenced and included the level of grip using Schneck and Henderson's Levels during a drawing accuracy test. Drawing accuracy was measured by a 6 point scale. - Grip level and accuracy level correlated only at extremes, that is highest (i.e. most mature) grip group had best accuracy. - No consistency with all other grips and drawing accuracy. - Increasing grip diameter decreased grip level but not accuracy	CONCLUSIONS: Children with graphomotor performance deficits are not likely to benefit from grip manipulations. LIMITATIONS: - Study used pens instead of pencils as they accommodated the various grips, however some children had to change the angle of their grip since the ball point wouldn't write at shallow angles. - Study did not directly test handwriting - Small sample size - Potential rater bias. - RECOMMENDATIONS: Further research needed on relationship between grip, legibility and speed.
Case-Smith, J. (2002)	-To study the effect of school-based	N= 38 Students ages	Level 4	Intervention involved handwriting practice,	Outcomes measures used the ETCH, manuscript and	CONCLUSIONS: Students who received OT services

23	occupational therapy on students' handwriting	7-10 with handwriting difficulties were compared to students who did not have difficulties from 5 different school districts. Pretest/posttest design.		visual-motor activities and sensory integration. Treatment occurred over entire year for 16.4 sessions and 528 minutes of direct occupational therapy.	cursive. -Significant gains in handwriting legibility in treatment group compared to control group Significant gains in total letter legibility in treatment group over control group	improved letter legibility, but not speed and numeral legibility. LIMITATIONS: - Control group not similar in size - Sample size was not geographically diverse - Descriptive findings - Did not differentiate visual-motor training from handwriting practice RECOMMENDATIONS: Specific handwriting interventions should be studied.
Cole, P.A. (2005)	-To determine if participation in fine or gross motor occupations affect legibility of first graders.	N=52 students from 4 different first grade classrooms were assigned to one of 3 groups. One-year study. Pretest-posttest design. Convenience sample.	Level 5	Students were assigned to either: 1) pre-writing program based on Benbow's techniques, including neurokinesthetic fine motor strategies 2) pre-writing program with Brain Gym methods of neurokinesthetic gross motor movements; 3) Control group -Pre-writing programs in the classroom were taught by teachers daily for 3 weeks prior to typical handwriting instruction.	Outcomes were measured by The Test of Handwriting Skills. -Only one subtest of the THS showed any difference between pre and post tests. -No correlation was demonstrated between experimental groups and control groups regarding handwriting legibility.	CONCLUSIONS: Neither the addition of a gross or a fine motor program before handwriting instruction affects the legibility of handwriting in first graders. LIMITATIONS: - Small sample size - Bias could be present. The researcher was not blind to the purposes of the study or the assignments. - It wasn't clear how the children felt or how actively they engaged in the motor programs. - Training of the investigator regarding the Benbow and Brain Gym programs was not discussed. RECOMMENDATIONS: Further research into prewriting programs is needed.
Dennis, J. L. & Swinth, Y. (2001).	-To study the influence of pencil grasp on handwriting legibility during	N=46 fourth grade students in regular education. Quasi-	Level 3	Intervention used regular writing assignments in cursive. - Students with atypical grasp were identified by	Outcome measures used the ETCH and showed significant differences in letter and word legibility between short and long tasks regardless of pencil	CONCLUSION: Type of grasp did not affect legibility. Decreased legibility was noted in longer writing tasks using either a dynamic tripod grasp or an atypical grasp.

	short and long writing tasks	experimental, mixed repeated measures design. Control group was matched. Evaluators were blind to the grasp type while scoring.		the researcher and then observed on both short and long writing tasks. -Photocopies of writing samples were given to evaluators.	grasp pattern. -Increased legibility was noted on shorter writing tasks. - Legibility scores were determined by the ETCH and researcher opinion.	<p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Subjective scoring - Small sample size <p>RECOMMENDATIONS:</p> <p>Research on combined effect of pencil grip on endurance and legibility may be helpful information when planning treatment options.</p>
Denton, P. L., Cope, S, & Moser, C. (2006)	-To investigate the effects of 2 interventions (sensorimotor and therapeutic practice) on handwriting in elementary age children.	N=38 children, ages 6-11 with no physical problems other than poor handwriting. Randomized controlled testing with blinding of assessors. Pre-post test.	Level 2	<p>THS-Test of Handwriting Skills was used to qualify students.</p> <p>Both groups received 30 minutes of intervention 4X/wk for 5 weeks.</p> <p>Sensorimotor intervention focused on visual perception, visual-motor integration, proprioception/kinesthesia and in-hand manipulation.</p> <p>Therapeutic practice group focused on letter practice, structured feedback and self-evaluation.</p> <p>Control group had normal classroom activities.</p>	<p>Outcome measures used THS and assessed writing from memory, dictated writing and copied writing, DVTP-2 to measure visual perception, Test of manual Pointing for proprioception and the In-Hand Manipulation test.</p> <p>-The Therapeutic group had a statistically significant difference in handwriting from sensorimotor, but not from control group.</p> <p>-Handwriting performance declined in the sensorimotor group.</p>	<p>CONCLUSIONS:</p> <p>Therapeutic practice resulted in modest improvements in children's handwriting when compared with sensorimotor interventions.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Small sample size - Unequal control sized group, ages, and other demographics - Some children received individual intervention and some received group intervention. - Three different measures of the THS were combined for outcome measure purposes, and may have skewed the results, especially as no differences were seen between Therapeutic group and control <p>RECOMMENDATIONS:</p> <p>More studies comparing motor learning approach and sensorimotor approach are needed.</p>

Erhardt, R. P. & Meade V. (2005)	-To describe an alternative approach to improving handwriting without actually teaching handwriting.	Case study of a 13 year old boy. Scoring of handwriting samples was done by the author of the MHT. (not these researchers) following 5 months of home exercises.	Level 5	The intervention started as collaboration between the PT and OT. Implementation occurred through a home program. - 30-45 minutes/day 5-7 days per week, supervised by OT for 5 months of combined postural, movement and fine motor-perceptual activities. - Use of Visual-Perceptual-Motor Activities Collection, adding 2-3 new activities/therapy session.	Outcome measures used the Minnesota Handwriting Test and the Purdue Perceptual Motor Survey. - Strong improvement was noted in alignment and size of letters - Moderate improvement was noted in legibility, form and spacing	CONCLUSION: Improvements in handwriting could result through a collaborative effort between physical therapy, occupational therapy and home. LIMITATIONS: - Relies on significant commitment by family - Very small sample - Subjective scoring - Statistical support of impressions was not offered. - Halo effect possible - Improvement could be attributed to task variables RECOMMENDATIONS: Isolate variables.
Graham, S., Harris, K. R., Mason, L., Fink-Chorzempa, B., Moran, S. & Saddler, B. (2007).	-To determine the effectiveness of handwriting instruction in handwriting and compositional fluency.	N= 38 first grade children in 12 classrooms in 4 schools within one school district. Experimental training study. Pretest/posttest.	Level 4	Intervention included 27 (3X/wk) 15-minute individual sessions. Lower case letters with common formational characteristics were taught in groups of 3 in frequency of use sequence. Each lesson included alphabet practice along with tracing, copying, self-appraisal and teacher correction.	Outcomes measured were Criterion Referenced and included # of letters made in set time and legibility. -Significant improvement in handwriting as reflected in alphabet production and total number of alphabet letters copied correctly. - Gains in handwriting were maintained 6 months later.	CONCLUSION: Supplemental handwriting instruction had a pronounced effect on all measures of handwriting performance LIMITATIONS: - Attrition - Small sample size RECOMMENDATIONS: Future research should attempt to isolate variables considered effective in promoting handwriting.
Goldberg, E. R. & Simmer, M. L. (1999)	-To compare the speed and legibility of handwriting produced by children involved in traditional instruction (TI) versus whole-language instruction (WLI)	N=44 TI students in grade 4 and 5 or 7 and 8 were paired with WLI students on the basis of age, sex, grade and hand dominance from 2 different schools.	Level 4	TI students were exposed to 2 sessions of daily in-class group instruction lasting 15 minutes each. Lower group - Grades 4 and 5. Upper group – Grades 7 and 8. Presharpened HB pencils were used for all groups. Passages were selected from Woodcock Mastery	Outcome measure was Test of Legible Handwriting (TOLH) and was used to code legibility and word count under speed. - Word count was computed for speed samples. -Results showed that TI students produced more legible handwriting than WLI students. -TI students wrote more words under time pressure than WLI	CONCLUSIONS: Students exposed to traditional handwriting instruction produced more legible handwriting than those educated under whole language conditions. LIMITATIONS: - Less 'legible' writing does not necessarily mean illegible. - Small sample size - Study itself points out the importance of handwriting

		All participants provided samples of 1) their best cursive; 2) the typical cursive; 3) cursive writing under the pressure of speed. Raters(2) were trained.		Tests, appropriate for each grade. Children were instructed to write in cursive from dictated passages but that punctuation and spelling would not be marked. Samples were obtained in the same order for each group—best, typical then speed.	students. - Differences between groups were consistent across grade and age.	instruction in itself, but does not compare instructional methods, nor address remediation. RECOMMENDATIONS: Further studies are needed matching subjects for intellectual ability and achievement.
Jackson, K. & Hughes, H. H. (1978)	-To determine the effect of relaxation training on cursive handwriting of fourth graders.	N=20 3 groups from one fourth grade class in one school. Two had poor handwriting; third group was control. Random assignments. Rater training, reliable and blind. Pretest/posttest. Correlation.	Level 2	Intervention consisted of 3 groups: 3X/wk for 3 wks. 1) Experimental group—children with poor handwriting who listened to relaxation tapes before writing as a group. 2) Control group with poor handwriting, but no treatment other than regular handwriting instruction. 3) No treatment group with average handwriting skills.	Outcome measures were Criterion Referenced and included quality of cursive handwriting: slant, uniformity, formation, spacing and general excellence. -Significant improvements noted in experimental groups on all qualities of handwriting over non-treatment or control group. -No change noted in the no-treatment control group. -Significant improvement of handwriting for average group, however at posttest, there was not difference between the average group and the experimental group.	CONCLUSION: Relaxation training is effective in improving quality of cursive writing if done before writing tasks for fourth graders. LIMITATIONS: - Well-designed study. - Sample sizes were small - Limited age groups RECOMMENDATIONS: Further research is needed on levels of muscle tension during relaxation training to better measure effect changes. Also, effect of relaxation training on different ages is needed, as is a more current and larger repeat study to confirm these results.
Hughes, H. H., Jackson, K., du Bois, L. E. & Erwin, R. (1979)	-To determine whether EMG biofeedback training is effective in treating handwriting problems	N=9, 4 girls and 5 boys in Grade 4. Correlation study.	Level 4	Biofeedback was used to promote relaxation during cursive handwriting practice.	Outcome measures were Criterion Referenced and included 5 different characteristics of cursive handwriting. -4 out of 5 qualities of handwriting showed improvement -Significant reductions in EMG levels (indicating stress)	CONCLUSIONS: Biofeedback and relaxation training are suggested to impact self-control, which in turn, impacts quality of cursive writing. LIMITATIONS: - May be impractical to use biofeedback in classroom RECOMMENDATIONS:

					were obtained between initial baseline and last training session.	The need for a carefully designed research study comparing EMG feedback and relaxation training is indicated.
Koziatek & Powell (2003).	-To study how speed and legibility of fourth graders cursive writing was affected by the type a pencil grip.	N=101 fourth grade students; 38 used a dynamic tripod grip; 18 used a dynamic quadrupod grip; 21 used the lateral quadrupod; 22 used a lateral tripod; 1 used a four-finger grip; 1 used an interdigital grip; Coorelational research; Researcher was blind to student's pencil grip	Level 3	Intervention involved a photograph of each student's pencil grip at close range. - Each student completed the ETCH-cursive	Outcome measures used the ETCH-c and included legibility and speed. - Students using the lateral quadrupod pencil grip scored highest for total words and letter legibility among students using mature pencil grips - One student using the four-finger grip scored the highest of all. - While there were some percentage differences between the scores, there was no statistically significant difference between the performances of those using a mature versus an atypical grip.	CONCLUSIONS: Lateral quadrupod and four-finger pencil grips were as functional as the dynamic tripod, lateral tripod and dynamic quadrupod pencil grips. LIMITATIONS: - Limited age range - Only looks at cursive writing RECOMMENDATIONS: Further studies are needed on the effect of endurance, comfort and pain as a product of varied pencil grip, and the resultant impact on legibility.
Jongmans, M. J., Linthorst-Bakker, E. & Westenberg, W. (2003)	- To investigate the effect of a task-specific self-instruction intervention to improve handwriting ability of children with handwriting problems in regular education (Study 1) and special education (Study 2).	Study 1, N = 14, 7 students who scored in the dysgraphic category on the BHK and 7 who had no problems; Same school. No prior OT/PT. Study 2, N=145 children, grades 2-6. Two different schools.	Study 1- Level 4 Study 2- Level 4	The BHK, also known as Concise Assessment Scale for Children's Handwriting, is a screening tool. -Students are trained to 1) Identify starting and ending points and produce letters of similar sizes; 2) Self-evaluate best letters in isolation or in pairs; 3) Reflect on quality of words and sentences. -Study 1 intervention consisted of 18 lessons, 2 sessions per week, each	Outcome measures used the BHK and included quality and speed of writing. - Study 1 students who received handwriting intervention on an individual basis for 3 months showed qualitative improvements more than the control group. - 3/7 students in Study 1 no longer needed intervention at the end of the study. - Study 1 control group improved more on speed - Study 2 students improved their quality of writing more	CONCLUSIONS: Remediating handwriting through a task-oriented self-instruction method is effective for quality in terms of spacing and letterforms, not for speed, among students identified as having poor handwriting. -Built on theory of motor learning. LIMITATIONS: - Not all students attended all sessions - Study 1 sample size was small. RECOMMENDATIONS: Further studies utilizing randomized

28		No prior OT/PT. Study 1-Pre-post test design. Study 2- quasi-experimental case-control design.		30 minutes for 3 months in school. -Study 2 intervention was conducted in a group setting 2X/wk 30 min. each for 6 months.	than control group, but writing speed was not significantly different between the test and control group.	sampling to separately study visual (e.g. directional arrows, letterform models, etc.) versus verbal cuing (e.g. teacher versus self) is needed.
Lockhart, J. & Law, M. (1994)	-To evaluate the effectiveness of a multisensory writing program for improving cursive writing ability in boys with sensorimotor difficulties.	N=4 A single case study experimental design. One school system. Evaluators (parents and assistants) were trained in scoring and blind to the study.	Level 4	-Intervention was 5 one-hour sessions held within school, same time every other week. -Letters were introduced in groups similar to Benbow's sequence (e.g. Loops and Other Groups). -Sessions were led by same researcher and followed the same format: 1) Tracing large letters on a blackboard with chalk; 2) Tracing letters over a rough surface with marker 3) Forming letters in rice with a finger 4) Copying large letters and letter groups on paper over a rough surface 5) Tracing and copying single letters and letter groups on lined paper -Homework nightly 15 minutes	Outcomes measured used the TOWL and included quality (and speed) of cursive writing of 5 distinct letter groups -Baseline data collected before study and after introduction of each group of letters. -Combinations of 2-4 letters in each group were presented in manuscript for copying in cursive. -Statistically significant change in letter quality on 3/5 letter groups for child 1, 5/5 for Child 2, and no significant change for Child 3 or 4. -No statistically change in speed for any of the children. -All Teachers reported noticeable changes in all children's writing, in spite of statistical results.	<p>CONCLUSIONS: Inconclusive findings, although teachers reported that intervention may have had a positive effect on self-confidence in writing, but only one study showed significant changes.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Small sample size - May need longer baseline data collection time - Training time may need to be extended - Insufficient evaluator training <p>RECOMMENDATIONS: More research is needed to determine if multisensory stimulation contributes to the feedback loop necessary for motor learning.</p>
Marr, D. & Dimeo, S. B. (2006)	-To examine the benefits of a summer handwriting instruction course	N=26 students Pre and posttest design of a single group of students grade 1-4. Retesting was done 3 months after instructional	Level 4	-Children attended a one-hour per day handwriting instruction program for 2 weeks using the Handwriting Without Tears curriculum manuscript or cursive. Initial Instructions were given on pencil grip,	Outcomes were measured through the ETCH. Parents were also asked to rate their children's performance. -Significant improvements noted in upper and lower case letter formations after 2 weeks. -Parent perception of	<p>CONCLUSIONS: A summer training program can be an effective way to improve individual letter quality in upper and lower case for manuscript, and lower case for cursive.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - No control group. - Potential bias by researcher and parents.

		program was completed.		posture and instruction of letter formation. Gross and fine motor warm-up exercises preceded practice. First week emphasized letter formation. Emphasis on the second week was writing sentences and paragraphs. Homework was given nightly.	improvements lasted 3 months posttest. -Cursive group did not make significant progress with upper case letter formations -No overall improvements were noted in sentence or paragraph legibility.	<ul style="list-style-type: none"> - Limited sample size. - Parents responded to a flyer and were therefore interested in the study. All students were identified by parents as needing handwriting remediation - Compliance with homework not reported - Study time was too short - Did not look at individual variables. - ETCH may not be valid for outcome measures <p>RECOMMENDATIONS: Control group. Increase instructional time. Increase group size. Use different outcome measurement.</p>
Marr, D. & Cermak, S. (2003)	- To Examine the consistency of handwriting in children from the beginning of Kindergarten to the middle of first grade	N=93 K students. Pre-test-post test. Longitudinal Study, descriptive design	Level 4	- No intervention. Students were given the SCRIPT by the same person at both points in time.	Outcome measures used the SCRIPT and were consistent for each group. -Improvements were noted for the lowest and middle group; the highest group continued to be high, but unchanged	<p>CONCLUSIONS: Moderate consistency exists in handwriting performance from Kindergarten through first grade.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Instructional program offered during the school year was not the same. - Maturation rate is different. - Did not control for sex <p>RECOMMENDATIONS: Expanded demographics needed in another longitudinal study.</p>
Massengill, D., & Sundberg, M. L. (2005)	-To demonstrate the effectiveness of integrated alphabet instruction in reducing letter sound and formation errors.	Group 1 N=78 first grade students in one suburban school district in the Midwest previously instructed in D'Nealian. Group 2	Level 5	Group 1 Baseline data collected after 5 months. Group 2 Baseline data collected at the beginning of summer. Intervention combined Lippincott phonics with D'Nealian writing by	Outcome measures were Criterion Referenced and included number of letter formation errors. -Improved letter size -Improved capital use -Improved lower case letter formations. -Decreased reversals	<p>CONCLUSIONS: The integrated alphabet approach improved learning of letter sounds and correct formation.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Poorly designed study - No further background information given on students, teachers or investigators - Inadequate description of

		N= ? Children from an inner city summer school, previously instructed in ball & stick printing. Descriptive statistics.		focusing on counter-clockwise movements in combination with diagonal lines and continuous as they cross midline—an intersensory approach, rather than a multisensory one.		methodology RECOMMENDATIONS: Further experimental research needed to determine effect size of integrated alphabet approach.
Park, C., Weber, K. P. & McLaughlin, T. F. (2007)	-To determine the effectiveness of fading, modeling, prompting and direct instruction of letter legibility for 2 preschoolers with physical and developmental delays.	N=2 Preschoolers enrolled in special education class. Multiple baseline single case design.	Level 3	Baseline data collected one week before intervention. - Number of letters in name written correctly was compared to the number of letters written. -Data was collected for 4 days a week for 5 weeks. -Students were presented with paper that had 4 rectangles into which they were to write their names. A model of their names was at the top of the page. -Model, dotted trace lines, verbal prompts and direct instruction was used for each letter. -Prompts and dotted lines gradually faded.	Outcome measures were Criterion Referenced and included number of letters of child's name written. Legibility was determined by school and district standards for kindergarten. - Overall increased legibility and printing of all letters in names - Learning of new letters was at an accelerated rate according to daily progress monitoring.	CONCLUSIONS: Direct instruction combined with modeling, verbal prompts and fading can help preschoolers with disabilities to write legibly. LIMITATIONS: - Very small sample. - Subjective measures RECOMMENDATIONS: Repeat study with larger sample and higher grades.
Peterson, C. Q. & Nelson, D. (2003)	-To evaluate whether and OT intervention improved printing in a school setting of educationally disadvantaged students.	N= 59 first grade students from economically disadvantaged areas, randomly assigned to treatment or control. Pretest/posttest design.	Level 2	Intervention combined biomechanical, sensorimotor and teaching-learning strategies. Intervention was 2X/wk for 30 minutes each for 10 weeks, including heavy work, sensory play and specific strategies.	Outcomes measures used the Minnesota Handwriting Test and included legibility, space, line, size and form. - Significant improvement of space, line and size - Changes in legibility and form were not significant.	CONCLUSION: OT intervention was effective in improving printing skills in children who are economically disadvantaged, some components more than others. LIMITATIONS: - Small sample - Did not discriminate between intervention strategies in results - Children in intervention group received more attention

						RECOMMENDATIONS: Sensitive measurements like the MHT could be used to assess effect of each biomechanical, sensorimotor and teaching strategy.
31 Ratzon, N. Z., Efraim, D. & Bart, O. (2007)	-To test the efficacy of a short-term treatment on the fine-motor and graphomotor skills of first-grade students.	N=52 Students who tested below the 21 st %ile on the VMI from schools within a low socioeconomic neighborhood. Pretest-posttest design with control group. 10 OT students administered the intervention	Level 3	Intervention included 12 sessions once a week for 45 minutes. The first 10-15 minutes were playful fine motor activities and the remaining 30-35 were paper-pencil tasks	Outcomes measured used Bruininks-Oseretsky test, including: 1) Eye-hand coordination-significant improvement in treatment group. 2) Significant improvement in copying skills in treatment group.	CONCLUSIONS: Occupational therapy intervention focused on fine and graphomotor skills can significantly improve performance of manipulative and copying skills of first graders. LIMITATIONS: - Did not measure handwriting as outcome - RECOMMENDATIONS: Test effectiveness of short-term visual motor treatment on handwriting. Test fine motor and gross motor effects separately on handwriting.
Roberts & Samuels (1993).	-To compare the effectiveness of computer-based handwriting exercises with traditional instruction	N= 36 students grades 4-6. Handwriting Evaluation Scale use to score samples. Testers were trained, blind and reliable. Pre-test, followed one month later by posttest.	Level 3	Intervention used 3 different instructional methods: 1) Apple Graphics Tablet, electronic pen and computer monitor tracked visible and invisible letters. 2) Conventional instruction with paper, plastic overlays and felt pens for copying and tracing 3) Conventional instruction using tracing and copying along with Touch window and stylus.	Outcomes measures used the handwriting Evaluation Scale and included letter closure, letter size, baseline orientation, letter formation. - Significant improvements via traditional methods vs computer exercises. - Parent and teacher ratings reflected agreement, that handwriting had improved in traditional group. - Traditional group showed significant improvements in size, baseline orientation and letter formation -Traditional group on computer showed significant improvement in letter closure.	CONCLUSIONS: Subjects did not benefit equally from the 3 treatment methods. Computer-based handwriting exercises do not demonstrate a greater improvement in handwriting. LIMITATIONS: - Small sample size - Apple graphics did not provide dependable kinesthetic feedback. - Difficult to implement in class - Costly RECOMMENDATIONS: Further research needed to delineate components of handwriting, and studied separately
Robin, A. L., Armel, S., & O'Leary, K. D.	-To investigate the effect of self-instruction and	N=30 Kindergartners from a local	Level 4	Group 1 received self-instruction with feedback, reinforcement and self-	Outcome measures were Criterion Referenced and included performance in	CONCLUSION: Self-instruction is an effective way to improve handwriting skills in kindergartners.

(1975)	direct training on writing deficiencies.	elementary who were identified as the 15 lowest scorers in a handwriting test from 2 classrooms. Children were randomly assigned to 3 groups, 10 each. Pre-post test.		instruction training. Group 2 received direct training with feedback and reinforcement. Group 3-Control. Testers worked individually with each child in direct training 3X/wk for 20 sessions. Testers trained self-instruction group in a 5-step procedure, including talking aloud and copying letters.	writing 4 uppercase letters they'd been trained in and 4 upper case letters they'd NOT been trained in. -Both intervention groups performed significantly better than the control group. -The self-instruction group performed significantly better than the direct training group	<p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Small sample size. - Evaluators were not blind to the study or group assignments - No uniformity of reinforcement - Verbal instructions were not clearly spelled out. - Self-instruction, as defined by this study, may be difficult to replicate in a real classroom on a regular basis. <p>RECOMMENDATIONS: Self-instruction in combination with direct instruction may be a more effective way to influence handwriting competence.</p>
Rosenblum, S., Goldstand, S. & Parush, S. (2006)	<p>-To determine if nonproficient handwriters could be distinguished by biomechanical ergonomic factors</p> <p>-To determine if a relationship exists between ergonomic factors, handwriting quality, efficiency and process</p>	N=50 proficient and 50 nonproficient third graders from 8 public schools in 4 different towns in Israel. This was a cross-sectional design, matching children by age, sex and grade. All students wrote and spoke Hebrew.	Level 3	<p>Both groups performed a handwriting task on an electronic tablet. Handwriting was evaluated using a computerized process. Same environmental conditions for all.</p> <p>-Each student was tested during one 45 minute session, while seated at a school desk appropriate for his height.</p> <p>-The paragraph copying task was presented visually on a computer screen.</p> <p>-Testing took 15 minutes immediately prior to testing, students engaged in other handwriting tasks for 25 minutes.</p>	<p>Outcome measures used the Hebrew Handwriting Evaluation (HHE) to 1) measure body posture, pencil grip, pencil positioning, and consistency of pencil grip, as well as legibility, 2) spacing and fluency (i.e. writing without pausing).</p> <p>-An independent researcher, blind to the group assignments, evaluated the handwriting quality.</p> <p>-Children with proficient handwriting scored better in all biomechanical ergonomic variables.</p> <p>-Significant correlations were found between body positioning, pencil position and consistency of pencil grip.</p> <p>-Handwriting efficiency correlations between all biomechanical variables, excepting grip.</p> <p>-Biomechanical factors</p>	<p>CONCLUSION:</p> <p>Nonproficient handwriters utilize inferior biomechanical ergonomics resulting in decreased quality and efficiency.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Limited sample size, age/grades, cultural backgrounds. - All participants were right handed <p>RECOMMENDATIONS:</p> <p>-Further studies needed comparing biomechanical ergonomic factors with cognitive and behavioral factors as well as with different intervention approaches.</p>

					<p>correlated with fluency. -Pencil grip did not correlate with fluency</p>	
<p>Sims Jr. & Weisberg, P. (1984)</p> <p>33</p> <p>33</p>	<p>-To study the influence of printed writing prompts on legibility.</p>	<p>Experiment I N=4 preschool children who had completed the Distar Reading I program. Within subject test design. Two Graders were trained and showed past agreement in scoring. Pilot Study.</p> <p>Experiment II N=18 second graders.</p> <p>Comparison design.</p>	<p>Level 5</p>	<p>Intervention involved worksheets that were taught and practiced for about 20 minutes per day. Letters were presented in order of frequency of use (e.g. m/a before g/j.) Page prompts included: 1) Dotted line for tracing. 2) Starting point with directional stroke and dark underline 3) Starting point with dark underline 4) Blank space with dark underline. Four Handwriting sheets presented 2 letters at a time using the Distar order. All 4 worksheets needed to be done</p>	<p>Experiment I- Outcome measures were Criterion Referenced and used a plastic overlay to score the proportion of the letter falling within the error band. A 5-point Likert Scale was used to code legibility. -Tracing correlated significantly with legibility and was more effective than starting points, directional strokes or blank space. -Writing with a starting point was better than writing on a blank space.</p> <p>Experiment II- Outcome measures were Criterion Referenced and used a 7 point Likert Scale. -Tracing better than copying, but copying with starting point was more effective than writing in a blank space. -No difference found between the 2 starting point prompts. -No difference in letter size from tracing or starting ball prompts, but letter size decreased on blank paper.</p>	<p>CONCLUSIONS: Page prompts may help children legibly print manuscript letters using correct directionality of stroke.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Scoring mechanism for letter accuracy was inaccurate. - Sample sizes on both groups was very small. - No clear description of intervention setting. - Possible evaluator bias. <p>RECOMMENDATIONS: Further research is needed to differentiate between the processes involved in copying and tracing. Studies are also recommended to understand why children tend to print smaller in blank spaces even when given visual models.</p>
<p>Sovik, N. (1981).</p>	<p>-To study the impact of individualized instruction in copying, tracking and handwriting.</p>	<p>N= 36 third graders, age 9 from 4 classes. Two classes received intervention, 2 did not.</p>	<p>Level 2</p>	<p>-Individualized instruction in handwriting was given to the 24 students in the classroom for 6 weeks. Twelve of these students also had individual laboratory time where</p>	<p>Outcome measures were Criterion Referenced and used accuracy of copying, tracing, tracking, handwriting quality and speed. -Results suggest that individualized training in</p>	<p>CONCLUSIONS: There was a significant difference between the accuracy of copying, tracking and writing skills among the experimental group compared to the control group.</p> <p>LIMITATIONS:</p>

		Children were grouped by sex and handwriting skills. Randomized controlled study. Pretest-posttest design.		they were trained in copying, tracing and tracking. Training focused on psychomotor skills and visual-motor skills.	copying and tracking improves skills in these areas and that the training transfers to handwriting. -No significant difference influence identified for tracing.	<ul style="list-style-type: none"> - The exact process or terms of copying, tracing and tracking were not defined operationally. - It was not reported whether the researcher or test administrators were blind to the group assignments. - There may have been outside activities ongoing that were not identified. <p>RECOMMENDATIONS: More research is needed on the effects of tracing and its ability to transfer into handwriting skills.</p>
Sovik, N. (1984).	-To study the effects of a remedial tracking program on writing performance of dysgraphic children.	N=12 Two groups of 9-year-old boys identified as having manual problems and low writing test scores from one school district in Norway. No randomization. Control group. Experimental design.	Level 3	-The experimental group did general exercises and individually traced, tracked and copied a figure, letter, word or word group. Feedback was given. Procedure was repeated 3 times. Individual exercises were similar but emphasized tracking and used equipment that provided sensory feedback.	Outcome measures were Criterion Referenced and used accuracy of writing and speed of writing. Pretest-posttest assessments were done in a clinic setting individually immediately after the study and as a group in the classroom 2 weeks after the study ended. Results showed that the experimental group scored significantly higher than the control group in writing accuracy.	<p>CONCLUSION: The research suggested that systematic, individualized training in tracing, tracking and copying would improve writing quality in students with dysgraphia.</p> <p>LIMITATIONS:</p> <ul style="list-style-type: none"> - Small sample size - Researchers and test administrators were not blind to the group assignments - It is unclear whether the participants were involved in related activities. <p>RECOMMENDATIONS: Repeat study with a larger sample size and blind evaluators.</p>
Sudsawad, P., Trombly, C.A., Henderson, L. & Tickle-Degnan, L. (2002)	-To investigate the effect of kinesthetic training on handwriting performance in first grade students 6-7 years of age who had kinesthetic deficits and handwriting difficulties.	N= 45 children from 24 elementary schools within 2 school districts, randomly and blindly assigned to 3 groups: kinesthetic	Level 2	-Treatment or practice was provided 30 min daily for 6 consecutive school days. -Two training tasks were presented in a counterbalanced order for the KST groups. -The handwriting group was given letters, words and sentences to copy	Outcome measures used the ETCH. Kinesthetic and handwriting legibility were measured 1 week before treatment, 1 week after treatment and 4 weeks after the posttest. Two standardized tests (KST- Kinesthetic Sensitivity Test and the ETCH) and a teacher questionnaire measured their	<p>CONCLUSION: Kinesthetic training did not improve handwriting legibility in first grade students any more than practice or no treatment.</p> <p>LIMITATIONS: The KST was not necessarily designed to measure handwriting. The Kinesthetic training did not seem directly related to handwriting, but rather to more gross motor movement</p>

		training group; handwriting practice group or no treatment group. A single trained scorer was used. -Permission was obtained for all children.		using either Zaner-Bloser, palmer or D'Nealian approaches as used in their classrooms. -No treatment group continued usual academic activities in their classrooms.	skills. -According to the ETCH, no significant difference was found between pre and posttest for kinesthetic group for legibility. - No significant change found from pre to posttest for near-point or far-point copying. -No significant improvement in handwriting speed.	patterns. The teachers reported improvement in legibility in all groups immediately after intervention and in follow-up, but their opinions may have been biased. RECOMMENDATIONS: No need for further training in kinesthesia as a precursor to handwriting.
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Hierarchy of Levels of Evidence for Evidence-Based Practice

Sources of Evidence	Classification
Strong evidence from at least one systematic review of multiple well-designed randomized controlled trials	I
Strong evidence from at least one properly designed randomized controlled trial of appropriate size	II
Evidence from well-designed trials without randomization, single group pre-post, cohort,	III

time series or matched case-controlled studies	
Evidence from well-designed non-experimental studies from more than one center or research group	IV
Opinions of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees	V

Note: Originally from Moore, A., McQuay, H. & Gray, J. A. M. (1995). Evidence-Based Everything. Bandolier, 1. 12., as cited in Holm, M. B. (2000).

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