Is Handwriting Causally Related to Learning to Write? 
Treatment of Handwriting Problems in Beginning Writers 

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The contribution of handwriting to learning to write was examined in an experimental training study involving beginning writers with and without an identified disability. First-grade children experiencing handwriting and writing difficulties participated in 27 fifteen-min sessions designed to improve the accuracy and fluency of their handwriting. In comparison to their peers in a contact control condition receiving instruction in phonological awareness, students in the handwriting condition made greater gains in handwriting as well as compositional fluency immediately following instruction and 6 months later. The effects of instruction were similar for students with and without an identified disability. These findings indicate that handwriting is causally related to writing and that explicit and supplemental handwriting instruction is an important element in preventing writing difficulties in the primary grades.

Horace Greeley, the founder of the New Yorker, often wrote notes and letters that were difficult to decipher. After writing a letter indicating that he would be unavailable to make a solicited presentation, he received a reply, noting that it took some time to translate his response, but that his requested date, terms, and honorarium were acceptable (Hendrickson, 1994).

Unfortunately, misinterpretations are not the only consequence of handwriting difficulties. For children, there are at least three additional unwanted results. First, poor penmanship may influence perceptions about a child's competence as a writer. When teachers or other adults are asked to evaluate two or more versions of a paper differing only in handwriting quality, neatly written papers are assigned higher marks for writing quality than papers of poorer legibility (e.g., Briggs, 1980; Chase, 1986; Hughes, Keeling, & Tuck, 1983). Second, difficulties with handwriting can interfere with the execution of composing processes during the act of writing (Graham, 1990; Scardamalia, Bereiter, & Goleman, 1982). Having to consciously attend to handwriting processes while composing may tax the writer's processing memory (see Berninger, 1999), interfering with other writing processes, such as generating content and planning. For instance, having to switch attention during composing to mechanical demands, such as having to think about how to form a particular letter, may lead the writer to forget ideas or plans already held in working memory. Third, and most important to the present study, handwriting difficulties may constrain a child's development as a writer. As Berninger, Mizokawa, and Bragg (1991) noted, difficulties in mastering handwriting skills may lead young children to avoid writing and develop a mind-set that they cannot write, resulting in arrested writing development. In addition, handwriting may require so much effort for some young writers that they develop an approach to composing (i.e., knowledge telling) that minimizes the use of other writing processes, such as planning and revising, because they exert considerable processing demands as well (McCutchen, 1996).

Graham and Harris (2000b) reviewed the evidence on the role of handwriting in children's development as writers. Consistent with the view that handwriting is an essential ingredient in writing development, they found that handwriting skills, particularly handwriting fluency (i.e., the amount of text that can be copied correctly per minute), improve with age and schooling (Graham, Berninger, Weirntraub, & Schafer, 1998; Hamstra-Blitz & Blote, 1990) and that individual differences in handwriting skills (again, most notably handwriting fluency) predict how much and how well children write (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Jones & Christensen, 1999). Additional correlational support was provided by Bourdin and Fayol (1993, 1994), who found that children were better at recalling information and generating sentences orally than in writing, whereas adults were equally adept with either mode of responding. Thus, the transcription processes of getting language onto paper, which included handwriting, appeared to impose a much greater cost on the composing of developing writers than it did with more skilled, adult writers.

Although these correlational findings provide support for the claim that children's competence in writing depends, at least in part, on their mastery of handwriting, only experimental training studies can shed light on the causal relationship involved. As Graham (1992) noted, improved handwriting can also be considered an outcome of providing children with frequent opportunities to write. Thus, if handwriting is causally related to writing, then
handwriting instruction should facilitate learning to write. We located two studies that assessed this proposition.

In a study by Berninger et al. (1997), first-grade children experiencing difficulty in mastering handwriting were randomly assigned to five handwriting treatment groups and a phonological awareness contact control condition. The handwriting treatments tested five alternatives for teaching the lowercase letters of the alphabet: (a) students write the letter after seeing the instructor write it, (b) students write the letter after examining a copy of it containing numbered arrows showing the order and direction for each stroke, (c) students write the letter from memory after examining an unmarked copy of it, (d) students write the letter from memory after examining a copy containing numbered arrows, and (e) students write the letter while looking at an unmarked copy. Students in the control condition received phonological awareness instruction that included identifying, segmenting, deleting, and substituting syllables and sounds in words. Specially trained tutors worked with 3 students in each treatment at a time, 3 days a week for a total of 24 sessions. Each session lasted for 20 min. During the first half of the session, either handwriting or phonological awareness was taught (depending on the group to which the students were assigned), whereas students wrote and shared their writing during the second half of the session.

All of the handwriting treatment groups made greater handwriting gains than the control group, with the most successful treatment being the one where the child wrote the letter from memory after examining a copy containing numbered arrows. This same group had higher scores on a standardized writing test, the Writing Fluency subtest from the Woodcock-Johnson Psycho-Educational Battery—Revised (WJ-R; Woodcock & Johnson, 1990), than students in either the phonological awareness control condition or the other handwriting groups. This finding is particularly noteworthy because it shows transfer from instruction in handwriting to composition fluency (i.e., the ability to generate written text), at least for the group that made the largest handwriting gains.

In the second investigation, Jones and Christensen (1999) found that instruction aimed at improving the handwriting skills of first-grade children with poor handwriting enhanced both their handwriting and story writing performance. Over the course of an 8-week period, students received handwriting instruction (individually or in a small group) from a parent volunteer or a teacher aide (10 min per day). Instruction concentrated on learning how to form the lowercase letters of the alphabet, correcting errors in letter formation, and writing letters fluently. At the end of the 8-week period, the handwriting and story writing quality (i.e., content and organization of text) of the children who received this special instruction improved to the point where it was indistinguishable from that of their regular peers who were initially better handwriting and story writers.

In addition to providing support for the theoretical claim that handwriting is a causal factor in learning to write, the studies by Berninger et al. (1997) and Jones and Christensen (1999) addressed an important practical issue as well. How can we prevent writing difficulties? In comparison to other academic areas such as reading (see Graham & Harris, 2000a; Fikulski, 1994; Snow, Burns, & Griffin, 1998; Wasik & Slavin, 1993), little attention has been directed to the issue of preventing writing difficulties (Graham & Harris, in press). The findings from the two studies just reviewed, however, indicate that supplementary handwriting instruction early in the primary grades may be a critical factor in preventing writing difficulties, at least for children who do not master handwriting easily. Nevertheless, additional research is needed to replicate as well as extend these two studies. Clearly, not all forms of handwriting instruction are effective in boosting writing performance, as only one of the approaches tested by Berninger et al. (1997) led to improvements in writing. In addition, neither study assessed whether handwriting instruction has more long-term effects on learning to write, as students’ performance was only checked immediately after instruction ended. Finally, both studies limited their examination to a single writing measure. It is possible that the effects of handwriting instruction are more pronounced for some writing variables than for others. For example, Graham et al. (1997) found that handwriting fluency was a better predictor of compositional fluency than of compositional quality.

In the present study, we examined the impact of supplementary handwriting instruction on the handwriting and writing performance of first-grade children who produced handwriting slowly and were also experiencing difficulty in learning to write. In addition to the handwriting instruction provided in the classroom, all of the participating children received additional instruction from a specially trained instructor three times a week. The supplemental handwriting program was developed so that it addressed basic processes identified in several influential data-based models of handwriting performance (Ellis, 1982; Margolin, 1984; van Galen, 1991). According to these models, writing a letter requires retrieving and holding the letter in working memory, accessing the corresponding motor program, setting the parameters for the program (e.g., establishing the size of the letter and speed of writing), and executing it. Correspondingly, students in the handwriting condition learned to name and identify the letters of the alphabet: were taught how to form each letter; adjusted parameters for speed or fluency by rewriting text at a faster pace; and practiced executing or writing letters in isolation, words, and sentences. These procedures were designed to teach students to write letters accurately and fluently.

Like the previous study by Berninger et al. (1997), students in the contact control condition received instruction in phonological awareness. This treatment was chosen because it is known to be beneficial to first-grade children (see Bus & van Ijzendoorn, 1999), and the data from the Berninger et al. (1997) study showed that teaching phonological awareness does not influence the process of learning to write letters.

We extended the studies by Berninger et al. (1997) and Jones and Christensen (1999) in three important ways. First, students with and without disabilities participated in the study, allowing us to determine whether the supplemental program was equally effective with both groups of students. Second, we used multiple measures of writing performance to assess the impact of supplemental handwriting instruction on learning to write. These included the Writing Fluency subtest from the WJ-R, a story writing probe (yielding a score for compositional fluency and a score for compositional quality), and a questionnaire designed to assess students’ attitude toward writing. Third, we examined whether the effects of supplemental handwriting instruction were maintained over time. Six months following the completion of instruction, all handwriting measures as well as the Writing Fluency subtest from the WJ-R and the writing attitude measure were readministered.
We anticipated that handwriting instruction would have a positive impact on the participating children's handwriting performance, leading to more accurate and fluent handwriting. It was also expected that handwriting instruction would lead to improvements in writing, as handwriting would require fewer attentional resources as it improved, allowing children to devote more resources to other writing processes. As McCutchen (1995) noted, until transcription processes, such as handwriting, become relatively automatic, they impose a significant drain on available resources and limit other writing processes, such as planning and content generation. However, we expected that the effects of handwriting instruction would be more pronounced for compositional fluency than compositional quality, as Graham et al. (1997) reported that individual differences in handwriting were a better predictor of output than quality. It was further predicted that handwriting instruction would be more pronounced for compositions in writing, as handwriting would require fewer attentional resources to other writing processes. As McCutchen (1995) noted, until transcription processes, such as handwriting, become relatively automatic, they impose a significant drain on available resources and limit other writing processes, such as planning and content generation. However, we expected that the effects of handwriting instruction would be more pronounced for compositional fluency than compositional quality, as Graham et al. (1997) reported that individual differences in handwriting were a better predictor of output than quality. It was further predicted that handwriting instruction would have a salutary effect on children's attitude toward writing, as learning to write letters more fluently and accurately should make writing more enjoyable. We anticipated that the hypothesized effects of supplemental handwriting instruction on both handwriting and writing would be maintained over time, as students who can write letters more quickly and accurately are more likely to write more and experience fewer negative experiences when learning to write. We expected that both students with and without disabilities would benefit from the supplemental handwriting program, as it taught skills that these students were having difficulties with in an explicit, organized, and detailed manner. A considerable amount of research demonstrates that a wide variety of children experiencing academic difficulties benefit from such instruction (see Brown & Campione, 1990). Finally, it was predicted that supplemental handwriting instruction would be a better predictor of outcomes at posttest and maintenance than child, family, or teacher variables. This is consistent with findings reported by Berninger et al. (1997), where treatment was the best predictor of improvements in handwriting and writing.

Method

Participants

Screening. Three hundred ten first-grade children in 12 classrooms attending four schools (in a single school district) located in suburban and urban middle-class neighborhoods outside of Washington, DC, were administered a timed handwriting screening measure at the end of January 1999. The screening measure assessed handwriting fluency. For this task, students were given primary-lined paper with a sentence typed at the top. After reading the sentence, students were directed to copy it as many times as possible during a 90-s interval. The score on this task was the number of letters copied correctly per minute. All handwriting samples were scored by Steve Graham (after all identifying information had been removed by the teachers), and half of them were rescored by a graduate student unfamiliar with the design and purpose of the study. Inter-rater reliability was .92.

The handwriting screening task was used to identify children as at risk in handwriting. To qualify as at risk, a child had to fall two thirds of a standard deviation below the class mean on the screening measure. Class means were used to assess at-risk status because classes differed in the amount of handwriting instruction provided by teachers. Class means ranged from 14 to 20 correct letters per minute. On the basis of these criteria, 42 children were identified as at risk for handwriting (teachers also confirmed that each of these students had handwriting difficulties). On average, they wrote 14.1 letters correctly per minute (SD = 4.2, range = 0 to 16). Their mean performance was considerably below the 19 correct letters per minute (SD = 7.0) obtained by 100 first-grade children completing a similar task in a study by Graham, Berninger, Weintraub, and Schaefer (1998). Parents of 38 of the children granted informed consent for participation in the study.

Groups. The 38 first-grade children granted informed consent were randomly assigned to two groups: handwriting and phonological awareness instruction. The mean age of participants was 6 years 9 months old. Twenty-two of the children were boys, whereas 12 were girls. This is congruent with a considerable body of research showing that girls are better handwriters than boys (Graham & Weintraub, 1996). Seventy-one percent of the students were Black, 21% were White, 5% were Hispanic, and 3% were of mixed race. The racial composition of the sample was consistent with that of the student body of the participating schools. Forty-eight percent of the participants received a free or reduced-cost lunch. Again this distribution was equivalent with that of the schools. Three percent of the sample were left-handed; this is less than the 10% typically found in the general population (Berninger, Cartwright, Yates, Swanson, & Abbott, 1994). Twenty-one of the participants received Reading Recovery services, and 14 students were identified as having a disability (3 of these 14 children received Reading Recovery services in addition to special education services).

Teachers also indicated that each child had difficulties with writing as well as handwriting. The results from a standardized writing test, the Writing Fluency subtest of the WJ-R, administered before instruction began (see the Measures section), generally confirmed the teachers' observations. The mean standard score of the 38 students was 91.3 (SD = 9.2). The mean for this test is 100 (SD = 15). Thus, the writing performance of the participating students was almost two thirds of a standard deviation below the normative sample.

Of the 14 students with a disability, 7 experienced speech and language difficulties, 3 were classified as having a learning disability, 3 were identified by a clinical psychologist as having an attention deficit hyperactivity disorder, and 1 received services for developmental disabilities. Examination of students' files indicated that a wide range of assessments had been used to identify and assess the children with special needs. Because there was minimal overlap in the measures administered from one child to the next, it was not possible to aggregate test scores for these students as a group or by disability category. However, all of the students with speech and language difficulties scored one standard deviation or more below the mean on a standardized test of language or speech functioning (e.g., Battelle Developmental Inventory, Developmental Indicators for the Assessment of Learning—Revised, Peabody Picture Vocabulary Test—Revised, Photo Articulation Test, or Test for Auditory Comprehension of Language—Revised). All 3 children with learning disabilities scored within the normal range on an individually administered intelligence test (e.g., the Wechsler Preschool and Primary Scale of Intelligence or the Wechsler Intelligence Scale for Children—Revised) and one or more standard deviations below the mean on a standardized achievement test (e.g., Wechsler Individual Achievement Test, WJ-R, or the Woodcock Reading Mastery Tests—Revised). The 3 children with an attention deficit hyperactivity disorder all took Ritalin and scored one or more standard deviations below the mean on the same measures administered to the children with learning disabilities. The child with a developmental delay scored two standard deviations below the mean on both the Battelle Developmental Inventory and the Test for Auditory Comprehension of Language—Revised.

Information on the characteristics of students by condition is presented in Table 1. Analysis of variance (ANOVA) showed that there were no statistically significant differences between students assigned to the two conditions for the handwriting screening score, writing performance on the WJ-R, or chronological age (all ps > .43). In addition, chi-square analysis showed that there were no statistically significant differences between the
two conditions in terms of gender, race, free and reduced-cost lunch, or disability (all ps > .16).

Instructional environment. The children’s teachers were queried to obtain information on how handwriting and writing were taught. All of the teachers indicated that they taught handwriting, but they differed in the amount of time spent teaching this skill. Three teachers indicated that they integrated handwriting instruction into their language arts program but were uncertain about how much time they spent teaching handwriting each week. They did indicate, however, that they taught handwriting at least weekly. For the other nine teachers, the amount of time spent teaching handwriting ranged from 30 min to 150 min a week, with a median of 50 min per week. Four of these teachers taught handwriting daily, three taught it several times a week, and two taught it weekly. Only three of the teachers provided additional handwriting instruction to the weaker writers in their classroom.

When teaching children how to form individual letters, the teachers modeled how to form the letter, discussed its characteristics with the child, and provided feedback on children’s efforts to copy or write the letter. In addition, students were asked to trace, copy, and write the letter from memory as well as evaluate their efforts. The only exceptions involved one teacher who did not use tracing and another teacher who did not discuss a letter’s characteristics or ask children to practice by writing the letter from memory. Eight of the teachers also indicated that they asked students to verbalize how to form the letter while practicing it.

All of the teachers reported that they taught writing, but the amount of time students spent writing each week ranged from 45 min to 6 hr (median writing time was 2 ½ hr per week). With the exception of one classroom, students were encouraged to select their own writing topics and frequently shared their writing with their peers. All but two of the teachers conferred with students about their writing at least once a week. All of the teachers encouraged children to use invented spellings and allowed them to complete writing assignments at their own pace. In 8 of the 12 classrooms, children frequently worked together when completing writing assignments, but the use of peer editing was infrequent. Explicit instruction was also a standard component of teachers’ writing program, with most teachers working on spelling, capitalization, punctuation, and grammar skills at least a couple of times a week. Instruction in planning and revising was less frequent, but usually occurred on a weekly basis. The only exceptions were three teachers who taught revising skills either monthly or several times a year. Neither word processing nor computers played a major role in the teachers’ writing program. However, three of the classes periodically visited a writing lab where students used a word processor to write.

Teachers were also asked to complete two questionnaires. The first instrument, the writing orientation scale (see Graham, Harris, MacArthur, & Fink, 2000, for technical data on validity and reliability), contains 13 Likert-type items designed to measure teachers’ views on the role of explicit instruction, natural or more informal methods of learning, and correctness in the teaching of writing. Examples of items assessing teachers’ views in each of these areas are “Formal instruction in writing is necessary to insure the adequate development of all the skills used in writing” (explicit instruction); “With practice writing and responding to written messages, children will gradually learn the conventions of adult writing” (natural learning); and “Before children begin a writing task, teachers should remind them to use correct spelling” (correctness). Scores for each item range from 1 (strongly disagree) to 6 (strongly agree), whereas the score for each scale (i.e., explicit instruction, natural learning, and correctness) is the average score for all items.

The students’ teachers strongly agreed that explicit instruction was an important component of a writing program. Their mean score on this scale was 5.5 (SD = 0.46), and none of the teachers’ scores were below 4.8. Although their mean score (M = 4.70, SD = 0.84) on the natural learning scale was lower, teachers also viewed incidental or informal learning methods positively. All of the 12 teachers’ scores were at or above the midpoint (i.e., 3.5). In contrast, the teachers were slightly negative about the role of correctness in writing instruction. Their mean score on this scale was 2.95 (SD = 1.08), and only 2 of the 12 teachers responded positively to the items on correctness. One teacher slightly agreed that correctness was important, whereas moderate agreement was evidenced by the 2nd teacher. The teachers’ responses to the items on the Writing Orientation Scale were consistent with their reports concerning their classroom practices.

The second instrument, the teacher writing self-efficacy scale (see Graham, Harris, Fink, & MacArthur, in press, for technical data on validity and reliability), includes 16 Likert-type items that measure teachers’ judgments about their competence as a writing teacher (personal teaching efficacy) and their capabilities to overcome familial factors (external factors). The following is an example of an item that assesses personal teaching efficacy: “When a student’s writing performance improves, it is usually because I found better ways of teaching that student.” An example of an item that measures external factors is “The influence of a student’s home experience on writing can be overcome by good teaching.” Scores for each item range from 1 (strongly disagree) to 6 (strongly agree), whereas the score for each scale (i.e., personal teaching efficacy and external factors) is the average score for all items.

In terms of personal teaching efficacy, the children’s teachers were generally positive in their assessments of their competence as a writing teacher. Their mean score on this scale was 4.83 (SD = 0.78). Only 1 of the 12 teachers’ scores (3.3) was below the midpoint (i.e., 3.5) on this scale. On the second scale, external factors, teachers’ scores were more variable (SD = 1.31) and slightly lower (M = 4.20) than their scores on the personal teaching efficacy scale. Nevertheless, the responses of 7 of the
Handwriting instruction consisted of 27 lessons that were divided into nine units (3 lessons per unit). In each unit, three lowercase letters were introduced and practiced. The only exception involved the ninth unit, in which only two letters were taught. Letters introduced in each unit were selected so that they shared common formational characteristics (Graham & Miller, 1980). For example, three letters with slanting lines were introduced in one unit (i.e., v, w, y), whereas three letters made with a backward circle were taught in another (i.e., c, d, g). In addition, easily confused or reversible letters, such as a and o or d and b, were not included in the same unit.

We used two criteria for determining the order in which the nine sets of letters (one for each unit) were introduced. First, we ranked ordered each set of letters by their frequency of occurrence in English words, using data collected by Zettersten (1969). Second, we again ranked ordered each set of letters according to their difficulty for young children, using data collected by Graham, Berninger, and Weintraub (2000). Using the information generated from these two activities, we attempted to assign letter sets to units so that the most useful and easiest sets of letters occurred first. Because the easiest letter sets were not always the most frequent, it was sometimes necessary to emphasize one criterion over the other. For instance, in assigning a letter set to the first unit, we started with the set of letters that was easiest (i.e., l, i, n) but ranked second in terms of frequency. The set of letters for each unit is as follows: Unit 1 (l, i, n), Unit 2 (o, e, a), Unit 3 (v, w, y), Unit 4 (p, h, f), Unit 5 (c, d, g), Unit 6 (b, u, m), Unit 7 (v, w, y), Unit 8 (x, k, z), and Unit 9 (i and y).

Each handwriting lesson in each unit contained four activities: Alphabet Warm-up (2 min), Alphabet Practice (6 min), Alphabet Rockets (5 min), and Alphabet Fun (2 min). The first activity, Alphabet Warm-up, focused on learning to name each letter of the alphabet, matching the name with its appropriate letter, and knowing the sequence of letters in the alphabet. Because the name of a letter is likely to serve as a cue for retrieving the motor program for writing it (Berninger & Graham, 1998; Graham, 1999), children needed to be fluent in naming, identifying, and accessing alphabet knowledge.

Students practiced four different tasks during Alphabet Warm-up. The first task involved the student singing the alphabet song while pointing to the corresponding letter on an alphabet chart. With the second task, the instructor said the name of a letter, and the child pointed to it on the alphabet chart. On the third task, the student wrote the letter, using an alphabet chart, and the student named the letter. The fourth task was a modified version of the alphabet practice game developed by Brooks, Vaughn, and Berninger (1999). The instructor would say a letter and ask what letter came before or after it in the alphabet. The child was initially encouraged to consult the alphabet chart for this task, but its use was faded as the student no longer needed it. For each task, the instructor provided feedback and assistance as needed. Students progressed through the tasks one at a time, not starting a second task until the previous one was mastered. Each student worked on all four tasks.

The second activity, Alphabet Practice, used an identical format for each unit. The first lesson contained five stages. First, using the index finger, the instructor traced and described aloud how to form each of the target letters (e.g., l, i, n), using cards with numbered arrows that showed the order and direction of strokes for each letter (model stage). Second, the student imitated the instructor, tracing each letter while describing how to form it (imitate stage). Third, the instructor and the student discussed how the formation of the target letters were similar and different (discuss stage). Fourth, on a practice worksheet, the student worked on one letter at a time: tracing with a pencil a copy of the letter that contained numbered arrows, then tracing three copies of the letter without numbered arrows, followed by writing the letter three times within the confines of an outline of the letter, and finally writing the letter three times on regular-lined paper (practice stage). During each one of these activities, the child was directed to say the name of the letter while either tracing or writing it. Fifth, for each target letter, the child circled the best letter written (evaluate stage).

Alphabet Practice for the second and third lesson of each unit was similar to the first lesson with the following differences. One, the third stage, discuss, was eliminated, and in the fourth stage, practice, the amount of practice in tracing and writing individual letters was reduced. In both the second and third lesson, the child traced with a pencil a copy of each target letter containing numbered arrows and then practiced writing each letter on regular-lined paper, circling the best written letter. Additional practice during the practice stage was provided by having the child copy words containing the target letters. During Lesson 2, this involved copying five words containing the target letters (e.g., all, ill, it, lill, little) for the first unit on l, i, n), whereas Lesson 3 involved copying three hinky-pinkys (e.g., tatt-fruition, willy-nilley, and polley-walley). The fifth stage, evaluate, was also modified so that students were directed to circle the best formed word. A final modification to Alphabet Practice during Lessons 2 and 3 involved the instructor using a highlighter to correct one or more miscues a student made when copying one of the words during the fourth stage, practice. This could include highlighting difficulties involving letter formation (e.g.,

1 All instructional materials and assessment protocols were written in Zaner-Bloser continuous script, as this was the script taught in the participating students' schools. We are indebted to Zaner-Bloser (Columbus, OH) for providing us with the alphabet cards and charts, pencils, and lined paper used in this study. Copies of the directions and worksheets for each unit are available from Steve Graham.
breaks, extra lines, etc.), slant, alignment, spacing, and size. For example, if the child failed to cross a t, the instructor would add the crossing using the highlighter, and the student would correct the misuse by tracing the highlighter mark with a pencil. Over the course of the study, 77% of highlighter corrections involved letter formation, 17% size, 4% spacing, and 2% slant.

The third activity, Alphabet Rockets, was designed to increase students’ handwriting fluency. During Lesson 1 of each unit, the student copied a sentence (26 to 34 letters long) that contained multiple instances of each of the target letters for that unit (e.g., Little kids like to get letters for Unit 1 on l, i, t). The child was directed to copy the sentence, quickly and without making mistakes, for a period of 3 min. The student and instructor then counted the number of letters copied and graphed the child’s performance on the first of three rockets on a performance chart.

Alphabet Rockets during the second lesson of a unit first involved reviewing with the child the number of letters written in the previous lesson and asking the student to beat his or her previous performance by three letters. Our goal was to help students obtain a gradual increase in their writing fluency, as a rapid increase in handwriting fluency can be accompanied by decrements in legibility (Weintraub & Graham, 1998). After the student wrote the sentence for 3 min, the instructor and student again graphed the child’s performance on the second rocket. If the child met the goal, the instructor drew a big star above the second rocket. Identical procedures were in effect during the third lesson, except the goal increased by three more letters if the goal was met during Lesson 2.

During the fourth activity, Alphabet Fun, students learned how to write one of the target letters in an unusual way (e.g., as long and tall or short and fat) or use it as part of a picture (e.g., turning an i into a butterfly or an r into a snake). If a student did not want to do this activity, he or she was allowed to practice writing the letter.

**Phonological Awareness Instruction**

Like handwriting instruction, the phonological awareness control condition included 27 lessons. Each lesson contained five activities: Daily Message (1.5 min), Letter Sound of the Day (1.5 min), Sound Play (7 min), Rhyming Triplets (2.5 min), and Sound Songs (2.5 min). With the exception of Sound Play, all activities were taken from the Ladders to Literacy Program (O’Conor, Notari-Syverson, & Vadasy, 1998). For the first 24 lessons, Sound Play consisted of four “sound games” derived from Rosner’s (1979) Auditory Analysis Program. These same four games were used in the study by Berninger et al. (1997). Activities for Sound Play in Lessons 25 through 27 were taken from the Ladders to Literacy Program.

With the first activity, Daily Message, the instructor wrote and read a personal message to the child (e.g., “Your blue shirt looks nice.”) containing the letter of the day (e.g., b). The instructor and student then read the message together. Next, the instructor wrote and named the letter of the day, and the child was asked to circle it.

During the second activity, Letter Sound of the Day, the instructor told the child the sound that the letter of the day makes and provided an example of a word that starts with that sound. The students were then asked to make the sound and identify other words that begin with the sound. If the child was unable to name a word, the instructor provided additional examples until the child was able to name appropriate words.

For the third activity, Sound Play, the child played four sound games. In the first six lessons, these sound games focused on syllables as in the following examples. In the first task, called Find the Hidden, the child was asked if a specific syllable was hidden in a word (e.g., “Is the word ant hidden in the word anthill?”). With the second task, Say the Missing, the student figured out which syllable was missing from a word (e.g., “Say Carelessly; now say lessly: what is missing?”). During the third task, Say the Word Without, the child was required to repeat a word without one of its syllables (e.g., “Say friendliness; now say it without ness.”). With the final task, Substitute, the student substituted one syllable for another in a word (e.g., “Say party; now don’t say it with y say it with neer.”).

Sound Play during Lessons 7 through 24 used the same four tasks but focused on phonemes. This included finding where specific phonemes were hidden (e.g., “Does the word big begin with a /b/ sound?”), figuring out which sound was missing from a word (e.g., “Say tin; now say it; what is missing?”), repeating a word without one of its sounds (e.g., “Say tin; now say it without /t/.”), and substituting one phoneme for another in a word (e.g., “Say tin; now don’t say it with /t/ say it with /d/.”).

In Lessons 25 through 27, two new tasks took the place of Sound Play. With the first task, Guess What Word, the instructor said a target word by first stretching the syllable (e.g., cat as /kcaat/), then saying the onset and the rhyme (e.g., /cl/ /a/), and finally by saying each phoneme (/cl/ /a/ /t/). Following this input, the child identified the word (from a list of four words) said by the examiner and then said the word, phoneme-by-phoneme, just like the instructor did. With the second task, Magic Squares, the instructor said a word (e.g., dog), sequentially said the sounds in the word (e.g., /d/ /o/ /g/), said the same sounds with the child, and asked the child how many sounds were in the word. The child and the instructor then said the sounds in the words again, with the student sequentially touching a square in an Elkonian box as each sound was produced.

With the fourth activity, Rhyming Triplets, the instructor said a pair of rhyming words (e.g., cake—make) and then asked the child to repeat them and other words that rhymed with them. In the final activity, Sound Songs, students substituted the letter sound of the day (from the second activity) with one of the sounds in well-known songs (i.e., Old MacDonald, Jimmy Cracked Corn, and the Birthday Song).

**Fidelity of Treatment Implementation**

To ensure that instructional procedures were delivered as planned, we implemented the following safeguards. First, instructors received intensive practice in applying all instructional procedures. Second, the instructors met with Steve Graham each week to discuss any glitches that occurred in implementing procedures. Reported glitches or deviations from instructional plans occurred rarely and typically involved an inadvertent mistake on the part of the instructor. Third, instructors were provided with a checklist for each lesson that furnished step-by-step directions. As they completed each step in a lesson, they were asked to check it off. Examination of these checklists once instruction ended showed that instructors completed 99.4% of the steps during handwriting instruction across lesson plans and 99.7% during phonological awareness instruction. Fourth, one third of all lessons were tape-recorded and checked to determine whether each step of a lesson was executed as intended by the instructor. The percentage of correct steps completed across lesson plans by the four instructors was 98.2% for handwriting instruction and 99.9% for phonological awareness instruction.

**Measures**

Each student was individually assessed before the start of instruction (pretest) at the beginning of February, after instruction ended (posttest) at the beginning of May, and again 6 months later (maintenance) at the start of November. The order of tests was counterbalanced, and tests were administered across a series of four to five sessions to minimize fatigue.

**Handwriting.** We used two timed tasks to assess students’ handwriting performance. For both tasks, students used a pencil without an eraser and primary-lined paper, and they were told to cross out and rewrite if they made mistakes. Both tasks were administered at pretest, posttest, and maintenance.

For the alphabet task (Abbott & Berninger, 1993), students were asked to print the entire lowercase alphabet as quickly as possible from memory without making any mistakes. Fifteen s after the child started writing the alphabet, a slash was made after the last letter completed, marking how many letters were written during the 15-s interval. Prior to the administration of the alphabet task, the procedures for marking the 15-s interval.
pictures were used to solicit stories. One of the pictures showed a turtle was recorded by the instructor. could spell a word on request but could provide no further help. In addition, tested, and interrater reliability between two scorers (Steve Graham and a provided, it does require text generation to link the provided words into a standard score, computed following the procedures in the test manual. The page contained all of the lower- and to name as many letters as possible from a page containing 52 letters (Juel, Griffith, & Gough, 1986). The page contained all of the lower- and uppercase letters of the alphabet, arranged in seven rows of letters, with 7 uppercase letters in each row (the order of letters was randomized). The student was directed to read across each row, naming each letter. After 1 min, testing was stopped. If the student named all 52 letters before the 1-min period ended, he or she was directed to return to the first row and continue naming letters. The score for this task was the number of letters correctly named in 1 min. The letter naming task was administered at posttest and maintenance. The task was scored by the instructor. Half of the recording sheets were rescored by a graduate student who was unfamiliar with the design and purpose of the study. Interrater reliability was 1.00.

Writing. Two tasks were used to assess students' composition or writing performance. The Writing Fluency subtest from the WJ-R was administered at pretest, posttest, and maintenance. With this test, children were asked to compose a sentence from three written words that go with a picture. The sentence was scored as correct if all three words were used without modification in a grammatically complete sentence. As specified in the test manual, testing was discontinued if three correct responses were not produced in 2 min, whereas an additional 5 min of testing were provided if this criterion was met or exceeded. The score for this test was a standard score, computed following the procedures in the test manual. Although this test entails little idea generation (planning) as words are provided, it does require text generation to link the provided words into a sentence (translation) under timed conditions (Beminger et al., 1997). The test–retest reliability reported in the WJ-R manual is .87 for the age group tested, and interrater reliability between two scorers (Steve Graham and a teacher unfamiliar with the design and purpose of the study) was .98.

For the story writing task, students were asked to write a story to go with a black-and-white picture. Before writing, they were told that the instructor could spell a word on request but could provide no further help. In addition, the amount of time each student spent completing the story writing task was recorded by the instructor.

Each child wrote two stories, one at pretest and the other at posttest. Two pictures were used to solicit stories. One of the pictures showed a turtle sitting in a tree with his arms crossed. The other picture showed a happy girl running in a field; she was accompanied by several animals, including a rabbit and a butterfly. Both pictures were line drawings. Prior to the start of the study, both pictures were judged to be appropriate for use with first-grade children by two primary grade teachers. The assignment of the two pictures was counterbalanced so that (a) each child responded to a different picture at pretest and posttest and (b) at each writing probe, an equivalent number of students in each condition responded to both pictures. This ensured that students always wrote a story in response to a new picture, while controlling for possible variations in students' writing performance due to differences in the content or the subject of the pictures.

Two scores were computed for the story writing tasks: compositional fluency and compositional quality. Compositional fluency was computed by counting the number of words the child wrote and dividing that by the amount of time spent composing, yielding a measure of the number of words written per minute. We decided to use this measure instead of simply counting the number of words written, as there was considerable variability in the amount of time students spent composing, ranging from 33 s to 15 min.

Compositional or story quality was assessed using a traditional holistic rating scale. Examiners were asked to read each story attentively, but not laboriously, to obtain a general impression of overall writing quality. Compositions were then scored on a 9-point scale, with higher scores representing higher quality of writing. In determining the score for each story, examiners were told that imagination, organization, aptness of word choice, grammar, and sentence structure should all be taken into account in forming a judgment about overall quality and that no one factor should receive undue weight. To guide the examiners in the scoring process, we provided them with a representative story for a score of 2, 4, 6, and 8.

These compositions were obtained from students in a first-grade classroom in one of the participating schools. This classroom did not participate in the study. All of the students in the classroom were asked to write a story in response to the same pictures used in the study. Two former elementary school teachers then selected the best, middle, and poorest stories on the basis of the scoring criteria noted earlier.

Before stories were scored they were typed (removing all identifying information) and corrected for spelling, punctuation, and capitalization miscues (to eliminate any bias in judgment on the basis of appearance and the surface-level features of text). All stories were scored for compositional fluency by Steve Graham, and half of these stories were rescored by a graduate student who was unfamiliar with the design and purpose of the study. Interrater reliability was .99. For story quality, all compositions were independently scored by two former elementary teachers who were unfamiliar with the design and purpose of the study. Interrater reliability was .82.

Attitudes toward writing. We adapted a scale for measuring attitude toward reading (McKenna & Kear, 1990) to develop an 11-item instrument to measure students' attitude toward writing. Items asked the child to answer the question "How do you feel . . .?" (a) "about writing for fun at home," (b) "when you write in school during free time," (c) "when you start to write a new paper," (d) "about writing during summer vacation," (e) "about writing instead of playing," (f) "about writing different kinds of papers," (g) "about writing in school," (h) "about spending free time writing," (i) "when it's time for writing at school," (j) "about the papers you write at school," and (k) "when you share your writing with others." Placed directly underneath each item was a picture of four Garfields. The first picture shows a very happy Garfield (big smile with hands raised high; score = 1), the second a happy Garfield (a less exuberant smile with arms crossed; score = 2), the third an unhappy Garfield (frown with hands crossed; score = 3), and the fourth a very unhappy Garfield (scowl with hands at side; score = 4). The instructor read each item to the student, and the child was asked to choose the Garfield that showed how he or she felt about each item.
Before administering the 11-item instrument, children were familiarized with the 4-point Garfield scale. The instructor modeled how to use the scale, and the child practiced using it to respond to two items: "How do you feel about eating spinach for breakfast?" and "How do you feel about playing with toys?" Students were encouraged to answer honestly. The participating students understood the procedures and did not experience any difficulties in completing the instrument. The writing attitude instrument was administered at posttest and maintenance.

To determine the factor structure of the writing attitude instrument, we conducted a factor analysis of the posttest responses for the 38 participants. First, an unconstrained principal factor analysis was used to generate the factor matrix with squared multiple correlations as initial communality estimates. Prior to rotation, the unconstrained principle factor analysis produced three factors with eigenvalues greater than 1.0. The three factors accounted for 64% of the total test variance. Based on a scree plot of eigenvalues, a one-factor solution was rotated by using the varimax criteria.

Results for the one-factor solution revealed that the varimax rotation accounted for 34% of the total test score variance. The eigenvalue was 3.75. The communality estimates for all items were above .20, except for two items: "How do you feel when you start to write a new paper?" (communality estimate = .15) and "How do you feel about writing during summer vacation?" (communality estimate = .17). Consequently, we recomputed the one-factor solution with the varimax criteria, eliminating these two items. The subsequent varimax rotation accounted for 38% of the variance (eigenvalue = 3.45). In addition, factor structure loadings for all items were .40 or greater (see Table 2). Coefficient alpha for the 9-item scale was .84.

Results

We first examined the effects of supplemental handwriting instruction on students’ handwriting, letter knowledge, and writing performance as well as their attitude toward writing at posttest. Effects on the measures administered at maintenance, 6 months later, were then examined. It should be noted that we were unable to obtain maintenance data for 6 of the students: 3 in the handwriting treatment condition and 3 in the contact control condition. Over the course of the summer, these children had moved. Examination of these 6 children’s pretest and posttest performance as well as information obtained from school files indicated that they were in all respects to the other students in the study. Finally, we examined whether treatment was a better predictor of achievement and attitude outcomes at both posttest and maintenance than child, family, and teacher variables.

Analysis of covariance was used to analyze the data for all handwriting and writing measures, allowing us to make adjustments for pretest differences between students in the treatment and contact control conditions. The independent variables were treatment (handwriting vs. phonological awareness) and student type (students with an identified disability vs. students without an identified disability). The covariance was the pretest for the corresponding variable. The homogeneity of slopes assumption was met for all analyses. ANOVA was used to analyze data for the letter knowledge and the writing attitude measures, as no pretest data were collected for these measures. Again, the independent variables were treatment and student type. To examine the relationship between predictor measures (i.e., treatment, child, family, and teacher variables) and outcome measures (handwriting, letter knowledge, writing, and writing attitudes) at posttest and maintenance, we computed Pearson product-moment correlations for continuous, quantitative variables and multiple correlations for dummy-coded variables for nominal indices.

Posttest

Means and standard deviations for each of the measures administered at pretest and posttest by treatment condition are presented in Table 3. As predicted, supplemental handwriting instruction had a more pronounced effect on all measures of handwriting performance at posttest than did instruction in phonological awareness. After adjusting for initial pretest differences, we found a statistically significant main effect for condition when examining alphabet production in 15 s, \( F(1, 33) = 17.50, MSE = 2.43, p < .001 \) \((d = 1.39)\); total number of alphabet letters written correctly, \( F(1, 33) = 16.92, MSE = 11.68, p < .001 \) \((d = 0.94)\); and total number of letters copied correctly per minute, \( F(1, 33) = 8.25, MSE = 116.52, p = .007 \) \((d = 1.46)\). In addition, on the two scores derived from the alphabet writing task, students without an identified disability outscored students who received special education services. After adjusting for initial pretest differences, there was a statistically significant main effect for student type on alphabet production in 15 s, \( F(1, 33) = 6.27, MSE = 2.43, p = .017 \) \((d = 0.54)\), and total numbers of alphabet letters written correctly, \( F(1, 33) = 4.81, MSE = 11.68, p = .035 \) \((d = 0.55)\). The adjusted means for students without an identified disability were 5.64 and 21.51 for the alphabet–15 s and total alphabet measures, respectively. For students with an identified disability, the respective means for these two measures were 4.33 and 18.99. The interaction between condition and student type was not statistically significant for any of the three handwriting measures. Thus, students with and without an identified disability benefited from supplemental handwriting instruction, but students without an

### Table 2

**Descriptive Statistics for the Nine-Item Writing Attitudes Scale**

<table>
<thead>
<tr>
<th>Item</th>
<th>M</th>
<th>SD</th>
<th>Factor structure loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do you feel about writing for fun at home?</td>
<td>2.03</td>
<td>1.22</td>
<td>.55</td>
</tr>
<tr>
<td>2. How do you feel when you write in school during free time?</td>
<td>2.74</td>
<td>1.25</td>
<td>.73</td>
</tr>
<tr>
<td>3. How do you feel about writing instead of playing?</td>
<td>2.71</td>
<td>1.27</td>
<td>.66</td>
</tr>
<tr>
<td>4. How do you feel about writing different kinds of papers?</td>
<td>2.13</td>
<td>1.23</td>
<td>.59</td>
</tr>
<tr>
<td>5. How do you feel about writing in school?</td>
<td>2.32</td>
<td>1.25</td>
<td>.70</td>
</tr>
<tr>
<td>6. How do you feel about spending free time writing?</td>
<td>2.39</td>
<td>1.31</td>
<td>.57</td>
</tr>
<tr>
<td>7. How do you feel when it’s time for writing at school?</td>
<td>2.26</td>
<td>1.20</td>
<td>.77</td>
</tr>
<tr>
<td>8. How do you feel about the papers you write at school?</td>
<td>2.03</td>
<td>1.13</td>
<td>.51</td>
</tr>
<tr>
<td>9. How do you feel when you share your writing with others?</td>
<td>2.00</td>
<td>1.29</td>
<td>.43</td>
</tr>
</tbody>
</table>

*Note.* Ratings were made on a 4-point scale, with lower scores representing more positive attitudes. From "Measuring Attitude Toward Reading: A New Tool for Teachers," by M. McKenna and D. J. Kear, 1990, *The Reading Teacher, 43,* pp. 630–634. Copyright 1990 by the International Reading Association. Adapted with permission.
identified disability obtained higher scores on the alphabet task at posttest than students receiving special services.

As expected, students in the handwriting group outperformed students in the phonological awareness group when asked to name as many written letters as possible in 60 s. Although there was a statistically significant main effect for condition, \( F(1, 34) = 5.76, \) \( MSE = 115.31, p = .022 \) \((d = .86)\), the main effect for student type was nonsignificant as was the interaction between treatment condition and student type.

Consistent with our predictions, supplemental handwriting instruction also led to greater gains in compositional fluency than did instruction in phonological awareness. After adjusting for initial pretest differences, we found a statistically significant main effect for condition when examining performance on the WJ-R Writing Fluency subtest, \( F(1, 33) = 4.56, \) \( MSE = 83.81, p = .04 \) \((d = .76)\), and the compositional fluency score on the story writing probe, \( F(1, 33) = 6.79, \) \( MSE = 2.61, p = .01 \) \((d = 1.21)\). It is interesting to note that the standard scores on the WJ-R for students in the handwriting condition improved approximately four tenths of a standard deviation in comparison to the performance of children in the control condition. Neither the main effect for student type nor the interaction between treatment condition and student type was statistically significant for either analysis.

Contrary to expectations, supplemental handwriting instruction did not result in a statistically significant improvement in story writing quality after adjustments for initial pretest differences were made. Likewise, the main effect for student type and the interaction were nonsignificant. For the most part, the overall quality of students’ writing remained poor, although there was considerable variability in quality scores (see Table 3).

Finally, there was a statistically significant interaction between treatment condition and student type on the writing attitude measure, \( F(1, 34) = 4.81, \) \( MSE = 0.62, p = .035 \). Analysis of simple main effects indicated that there was a statistically significant difference in the attitudes of regular and special needs students in the phonological awareness condition at posttest, \( F(1, 17) = 7.64, \) \( MSE = 0.47, p = .013 \) \((d = 1.11)\). For students receiving phonological instruction, children with an identified disability were more negative about writing \((M = 2.86)\) than children without an identified disability \((M = 1.95)\). In contrast, there was no statistically significant difference in the writing attitudes of children with and without an identified disability in the handwriting condition \((M = 2.39)\) for students without a disability, and \( M = 2.13 \) for students with a disability), nor was there a statistically significant difference between special needs students in the two treatment conditions or regular students in the two treatment conditions. In summary, students with an identified disability in the phonological awareness condition were slightly more negative about writing, whereas all other groups were slightly positive.

**Maintenance**

Means and standard deviations for each of the measures administered at pretest and maintenance by treatment condition are presented in Table 4. For the most part, the findings at maintenance parallel the posttest findings.

---

**Table 3**

**Means and Standard Deviations for Pretest and Initial Posttest Scores by Treatment Condition**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Handwriting Pretest</th>
<th>Handwriting Posttest</th>
<th>Handwriting Adjusted</th>
<th>Phonological awareness Pretest</th>
<th>Phonological awareness Posttest</th>
<th>Phonological awareness Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphabet (15 s)</td>
<td>( M = 90.58 )</td>
<td>( M = 96.79 )</td>
<td>( M = 97.06 )</td>
<td>( M = 90.45 )</td>
<td>( M = 97.06 )</td>
<td>( M = 90.84 )</td>
</tr>
<tr>
<td>( SD = 2.04 )</td>
<td>( SD = 2.43 )</td>
<td>( SD = 1.84 )</td>
<td>( SD = 1.67 )</td>
<td>( SD = 1.84 )</td>
<td>( SD = 1.16 )</td>
<td>( SD = 1.10 )</td>
</tr>
<tr>
<td>Alphabet total</td>
<td>( M = 17.26 )</td>
<td>( M = 22.89 )</td>
<td>( M = 22.62 )</td>
<td>( M = 16.37 )</td>
<td>( M = 18.26 )</td>
<td>( M = 17.86 )</td>
</tr>
<tr>
<td>( SD = 5.88 )</td>
<td>( SD = 3.26 )</td>
<td>( SD = 5.13 )</td>
<td>( SD = 4.56 )</td>
<td>( SD = 5.13 )</td>
<td>( SD = 4.56 )</td>
<td>( SD = 4.98 )</td>
</tr>
<tr>
<td>Copy text</td>
<td>( M = 27.53 )</td>
<td>( M = 40.47 )</td>
<td>( M = 39.87 )</td>
<td>( M = 25.58 )</td>
<td>( M = 28.63 )</td>
<td>( M = 29.39 )</td>
</tr>
<tr>
<td>( SD = 6.83 )</td>
<td>( SD = 15.09 )</td>
<td>( SD = 8.43 )</td>
<td>( SD = 10.18 )</td>
<td>( SD = 8.43 )</td>
<td>( SD = 10.18 )</td>
<td>( SD = 10.18 )</td>
</tr>
<tr>
<td>Letter knowledge</td>
<td>( M = — )</td>
<td>( M = 54.89 )</td>
<td>( M = 46.58 )</td>
<td>( M = — )</td>
<td>( M = 46.58 )</td>
<td>( M = 46.58 )</td>
</tr>
<tr>
<td>( SD = — )</td>
<td>( SD = 11.29 )</td>
<td>( SD = 9.63 )</td>
<td>( SD = 9.63 )</td>
<td>( SD = 9.63 )</td>
<td>( SD = 9.63 )</td>
<td>( SD = 9.63 )</td>
</tr>
<tr>
<td>WJ-R Writing Fluency</td>
<td>( M = 90.58 )</td>
<td>( M = 96.79 )</td>
<td>( M = 97.06 )</td>
<td>( M = 92.21 )</td>
<td>( M = 90.84 )</td>
<td>( M = 90.45 )</td>
</tr>
<tr>
<td>( SD = 9.44 )</td>
<td>( SD = 12.40 )</td>
<td>( SD = 9.16 )</td>
<td>( SD = 7.77 )</td>
<td>( SD = 9.16 )</td>
<td>( SD = 7.77 )</td>
<td>( SD = 7.77 )</td>
</tr>
<tr>
<td>Compositional fluency</td>
<td>( M = 3.11 )</td>
<td>( M = 4.42 )</td>
<td>( M = 4.41 )</td>
<td>( M = 2.77 )</td>
<td>( M = 2.94 )</td>
<td>( M = 3.00 )</td>
</tr>
<tr>
<td>( SD = 3.06 )</td>
<td>( SD = 0.89 )</td>
<td>( SD = 2.04 )</td>
<td>( SD = 1.22 )</td>
<td>( SD = 2.04 )</td>
<td>( SD = 1.22 )</td>
<td>( SD = 1.22 )</td>
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<tr>
<td>Compositional quality</td>
<td>( M = 2.11 )</td>
<td>( M = 2.95 )</td>
<td>( M = 3.08 )</td>
<td>( M = 2.92 )</td>
<td>( M = 2.97 )</td>
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<tr>
<td>( SD = 1.78 )</td>
<td>( SD = 1.36 )</td>
<td>( SD = 1.44 )</td>
<td>( SD = 1.50 )</td>
<td>( SD = 1.44 )</td>
<td>( SD = 1.50 )</td>
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</tr>
<tr>
<td>Writing attitude</td>
<td>( M = — )</td>
<td>( M = 2.29 )</td>
<td>( M = 2.29 )</td>
<td>( M = — )</td>
<td>( M = 2.29 )</td>
<td>( M = 2.29 )</td>
</tr>
<tr>
<td>( SD = — )</td>
<td>( SD = 0.87 )</td>
<td>( SD = 0.80 )</td>
<td>( SD = 0.80 )</td>
<td>( SD = 0.80 )</td>
<td>( SD = 0.80 )</td>
<td>( SD = 0.80 )</td>
</tr>
</tbody>
</table>

**Note.** There were 18 students in each condition. WJ-R = Woodcock-Johnson Psycho-Educational Battery—Revised. WJ-R Writing Fluency score is the standard score for first grade.
As expected, the gains in handwriting performance obtained at posttest were maintained 6 months later. After adjusting for initial pretest differences, we found a statistically significant main effect for condition when examining alphabet production in 15 s, $F(1, 27) = 7.06, MSE = 121.22, p = .013 (d = 0.70)$. The standard scores on the WJ-R for students in handwriting condition improved approximately six tenths of a standard deviation in comparison to the performance of students in the control condition, resulting in a mean standard score almost equal to that of the normative sample of the WJ-R (see Table 4). Neither the main effect for student type nor the interaction between treatment condition and student type was statistically significant.

Contrary to expectations, neither the main effects for treatment condition or student type nor the interaction between the two were statistically significant for the writing attitude measure. Students in both the handwriting and the phonological awareness group were slightly positive about writing at maintenance (see Table 4).

**Predicting Response to Intervention**

Nine variables were considered as potential predictors of treatment outcomes at posttest and maintenance. These included treatment, family, child, and teacher variables. At both posttest and maintenance, treatment was the best predictor of performance on the handwriting and writing measures. At posttest, there was a statistically significant relationship ($p < .05$) between treatment and alphabet letters written correctly in 15 s ($r = .50$), total number of alphabet letters written correctly ($r = .52$), number of letters copied correctly per minute ($r = .43$), letters named correctly in 1 min ($r = .38$), and compositional fluency on the story writing probe ($r = .41$). At maintenance, there was a statistically significant relationship between treatment and alphabet letters written correctly in 15 s ($r = .43$), total number of alphabet letters written correctly ($r = .41$), and writing fluency on the WJ-R ($r = .38$). These findings indicate that treatment conditions were effective in improving handwriting and writing fluency for students with and without disabilities.

### Table 4

**Means and Standard Deviations for Pretest and Maintenance Scores by Treatment Condition**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Handwriting</th>
<th>Phonological awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Maintenance</td>
</tr>
<tr>
<td>Alphabet (15 s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>3.47</td>
<td>5.93</td>
</tr>
<tr>
<td>$SD$</td>
<td>2.04</td>
<td>1.91</td>
</tr>
<tr>
<td>Alphabet total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>17.26</td>
<td>22.06</td>
</tr>
<tr>
<td>$SD$</td>
<td>5.88</td>
<td>3.34</td>
</tr>
<tr>
<td>Copy text</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>27.53</td>
<td>31.17</td>
</tr>
<tr>
<td>$SD$</td>
<td>6.83</td>
<td>8.29</td>
</tr>
<tr>
<td>Letter knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>—</td>
<td>64.23</td>
</tr>
<tr>
<td>$SD$</td>
<td>—</td>
<td>10.21</td>
</tr>
<tr>
<td>WJ-R Writing Fluency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>90.58</td>
<td>99.44</td>
</tr>
<tr>
<td>$SD$</td>
<td>9.44</td>
<td>13.40</td>
</tr>
<tr>
<td>Writing attitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>—</td>
<td>2.31</td>
</tr>
<tr>
<td>$SD$</td>
<td>—</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Note. There were 16 students in each condition. WJ-R = Woodcock-Johnson Psycho-Educational Battery—Revised. WJ-R Writing Fluency score is the standard score for first grade.
written correctly \((r = .45)\), and letters named correctly in a minute \((r = .39)\).

In contrast, few statistically significant correlations were found between the other predictors and the outcome measures. There was a statistically significant correlation between chronological age and the number of letters named correctly per minute at posttest \((r = -.32)\). In addition, the other child-related variable, gender, was significantly correlated with students' performance on the WJ-R Writing Fluency subtest at maintenance \((r = .39)\). With three exceptions, neither the family variable, free or reduced-cost lunch, nor the teacher variables, the two scores on the writing orientation scale or the three scores on the teacher writing self-efficacy scale, were significantly related to the outcome variables. Classroom emphasis on correct form in writing was negatively related to alphabet letters written correctly in 15 s at maintenance \((r = -.43)\), an emphasis on explicit writing instruction predicted number of letters named correctly in a minute at posttest \((r = .34)\), and an emphasis on the natural learning approach to writing instruction was positively related to students' attitude toward writing at posttest \((r = .35)\).

Discussion

Theoretical Implications

In this study, we examined whether handwriting is a causal factor in learning to write. Previous research has shown that individual differences in handwriting skills are related to how much and how well children write (see Graham et al., 1997; Graham & Harris, 2000b) and that early, supplementary handwriting instruction can boost the writing performance of poor handwriters immediately following instruction (Bernerger et al., 1997; Jones & Christensen, 1999). To assess the causal role of handwriting in early writing development, we provided supplemental handwriting instruction to first-grade children who were experiencing difficulty with handwriting and writing, and then we assessed the immediate as well as long-term effects of such instruction.

The findings from the current study indicate that handwriting is indeed causally related to learning to write. Students who received supplementary handwriting instruction outperformed their counterparts in the contact control condition (i.e., phonological awareness instruction) on measures assessing not only handwriting but writing skills as well. Immediately following instruction, students in the handwriting condition were more accurate in naming and writing the letters of the alphabet, and they were also able to produce the letters of the alphabet and copy connected text more fluently. With the exception of copying text more fluently, these handwriting gains were maintained 6 months later. Most important, handwriting instruction resulted in immediate as well as more long-term improvements in students' compositional fluency skills. On a story writing probe, students in the handwriting condition composed at a much faster rate than their peers in the contact control condition at posttest (this measure was not administered at maintenance). Moreover, on a norm-referenced measure of compositional fluency, the Writing Fluency subtest from the WJ-R, students in the handwriting condition were more skilled at constructing written sentences immediately after instruction and 6 months later. Consequently, the mastery of handwriting skills not only appears to facilitate the initial process of learning to write, as demonstrated by this and previous studies (Berninger et al., 1997; Jones & Christensen, 1999), but may also affect the outcomes of the learning process over time, at least up to a period of 6 months.

McCuthen (1995) and others (Berninger, 1999; Graham & Harris, 2000b) have argued that handwriting, especially when it is produced slowly, imposes a significant drain on the attentional resources of young writers and, consequently, limits their use of other writing processes. Although we were unable to assess the attentional resources needed for handwriting, the findings from this study are consistent with this view, as children's writing performance on two separate measures of compositional fluency improved as a result of handwriting instruction. Similar results were reported in an earlier study conducted by Berninger et al. (1997).

The data from the current study also suggest that the links between handwriting and the processes involved in shaping the overall quality of text are not as strong as those between handwriting and text generation. Students who received handwriting instruction did not produce qualitatively better stories than their counterparts in the contact control condition at posttest. This conflicts with the findings reported by Jones and Christensen (1999) that supplemental handwriting instruction had a positive impact on the overall quality of the writing of first-grade children who were poor handwriters. These contradictory findings may be due to differences in how writing samples were collected and scored in the two studies. We asked students to compose a story in response to a picture; typed each paper and corrected spelling, punctuation, and capitalization before scoring; and used a holistic approach to assess writing quality. Jones and Christensen directed students to write about their summer vacation; read papers aloud to scorers in place of typing and correcting their mechanical miscues; and used an analytic approach to scoring. The conflicting findings may also be a consequence of basic differences in the design of the two studies. We randomly assigned students with handwriting and writing difficulties to the two treatment conditions, and children in both conditions were told they were participating in a special program. The Jones and Christensen study was a quasi-experimental design, and students in the control condition served as a normative comparison group, as they were not experiencing any reported handwriting or writing difficulties and did not receive any special instruction. In any event, additional research is needed to resolve these contradictory findings and to further explore possible links between handwriting and the processes involved in shaping the overall quality of text.

Contrary to expectations, improvements in handwriting did not have a salutary effect on children's attitude toward writing. We had anticipated that handwriting instruction would enhance children's disposition toward writing, as learning to write letters more fluently and accurately should make writing a more enjoyable activity. The only statistically significant difference in writing attitude, however, occurred at posttest, when control students with an identified disability were less positive about writing than control students without an identified disability. No statistically significant attitudinal differences were found between students in the handwriting and the control condition at either posttest or maintenance. On the basis of these findings, it is also unlikely that the observed improvements in compositional fluency obtained by students in the handwriting condition were mediated by changes in...
attitude, as there was no evidence that this instruction influenced children’s disposition toward writing.

It is important to note that the long-term effects of handwriting instruction were less pronounced than short-term effects for several of the variables. The effect size for the number of alphabet letters written correctly in 15 s dropped from 1.39 at posttest to 0.87 at maintenance, whereas the effect size for naming the letters of the alphabet dropped from 0.86 to 0.65. In addition, handwriting instruction resulted in improved fluency in accurately copying connected text at posttest ($d = 1.46$), but a statistically significant difference on this variable was not maintained 6 months later, even though the effect size was 0.45. Similar outcomes have been observed in the area of phonological awareness, where instructional effects are stronger at posttest than at maintenance (Bus & van Ijzendoorn, 1999). With the exception of the copying task, however, effect sizes for each of these variables remained quite robust, and the instructional effects for the one compositional fluency measure (i.e., Writing Fluency subtest from the WI-R) that was administered immediately following instruction and 6 months later evidenced little change over time (the effect size was 0.76 at posttest and 0.70 at maintenance).

Finally, the generality of the claim that handwriting is a causal factor in learning to write is strengthened by the findings that both the handwriting and writing of students with and without an identified disability benefited from supplementary handwriting instruction. Although students with an identified disability were not as skilled as their nondisabled counterparts at writing the letters of the alphabet at posttest, handwriting instruction had a similar and positive effect on the handwriting and writing of both groups of children immediately following instruction and 6 months later.

**Educational Implications**

In recent years, there has been a tendency to downplay or even eliminate handwriting instruction as part of the writing program (Berninger, 1999; Graham & Weintraub, 1996), as approaches such as whole language and process writing have placed greater emphasis on content and process and much less emphasis on form. The findings from the current study as well as the investigations by Berninger et al. (1997) and Jones and Christensen (1999), however, indicate that such an approach may be ill-advised with beginning writers who experience difficulty in initially mastering the intricacies of handwriting. Students in these studies benefited from explicit and supplemental instruction in how to form and fluently write the letters of the alphabet, as they evidenced improvements in both their handwriting and compositional skills. Thus, if educators want to improve the writing of these students, they need to focus not just on the content and process of writing, but on transcription skills such as handwriting as well.

It is also tempting to assume that the development of handwriting skills can be ignored because of the advent of alternative modes of composing, such as word processing and speech synthesis (Graham, 1992). As one teacher told Steve Graham, “I don’t need to worry much about handwriting, because everyone uses word processing today.” Although the use of word processing and speech synthesis has clearly increased in recent years, beginning writers still, and for the foreseeable future, do most of their composing by hand. Unfortunately, the data from this study and clinical reports by others suggest that difficulties in developing adequate handwriting skills in the early grades may lead to arrested writing development, particularly in terms of compositional fluency. For example, third graders participating in a summer clinic at the University of Washington told investigators that they avoided writing, because their handwriting and spelling difficulties made it hard for others to read what they wrote (as reported in Berninger et al., 1997). Thus, until alternative methods of composing, such as word processing or speech synthesis, become the primary writing tool used by beginning writers, handwriting should not be ignored in the early grades.

The outcomes from the current study as well as the two prior investigations (Berninger et al., 1997; Jones & Christensen, 1999) further indicate that supplemental handwriting instruction is an important element in preventing writing difficulties, at least for children who struggle to master handwriting skills in the early primary grades. The finding that students with an identified disability were just as likely to benefit from additional handwriting instruction as their nondisabled peers is particularly important because handwriting and writing difficulties are quite common among these students (Graham & MacArthur, 1987). The short-term intervention applied in this study shows that it may be possible to raise writing performance relative to same-grade peers on a nationally normed test of compositional fluency. If compositional fluency can be raised by four tenths of a standard deviation at posttest and six tenths of a standard deviation 6 months later by 27 fifteen-min sessions, it may be possible to raise performance even more by providing a longer intervention. Such improvements in compositional fluency may be especially important for struggling writers, as research by Berninger and her colleagues (Berninger et al., 1991) indicates that compositional fluency problems in the primary grades may be the genesis for writing problems in the upper grades.

Additional research is needed to replicate the current findings and to develop other techniques for preventing writing difficulties. A recent study by Berninger et al. (1998) indicates that early, supplemental spelling instruction may also be important in the prevention of writing difficulties. Extra spelling instruction improved both the spelling and compositional fluency of second-grade students who were poor spellers. We further anticpate that early, supplemental instruction in the self-regulatory aspects of writing, particularly planning and revising, will help to prevent writing difficulties. Our own research has shown that struggling writers often experience difficulties regulating these processes when writing (De La Paz, Swanson, & Graham, 1998; Graham, 1997; Graham & Harris, 2000b) and that directly teaching these processes to older elementary-level students who are poor writers results in improvements in how much and how well they write (Graham & Harris, 1996). It is also likely that efforts designed to increase the quantity and quality of the regular writing program will be beneficial as well. Such instruction should reduce the number of cases of writing failure due to poor instruction and help ameliorate the severity of writing difficulties experienced by other children whose primary problems are not instructional.

In summary, explicit supplemental instruction that helps young children write letters accurately and quickly can increase the probability that they will become skilled writers. In the present study, such instruction was a better predictor of children’s success than student or family variables or even the teachers’ sense of
efficacy or their approach to writing. This study, along with the investigations by Berninger et al. (1997) and Jones and Christensen (1999), shows that explicit handwriting instruction is an integral component of an effective writing program for beginning writers.

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Received January 31, 2000
Revision received May 10, 2000
Accepted June 12, 2000