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Integration of Reading and Writing Instruction to Increase Foundational Literacy Skills: Effects of the "Write Sounds" Intervention on Handwriting, Decoding, and Spelling Outcomes

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Reading and writing rely on related foundational literacy skills (e.g., phonological processing, phonological memory, phonemic awareness). Therefore, students struggling with reading often have literacy difficulties that continue throughout their school years. However, lack of time and resources may make it difficult for schools to implement interventions for both reading and writing. Interventions that combine instruction for both skills may help to mitigate time and resource constraints. This paper reports the results of two pilot studies designed to examine the effectiveness of the Write Sounds integrated handwriting intervention for students with word-level deficits in reading and writing. Study 1 included 33 students struggling with handwriting and word-level reading or spelling difficulties in second and third grade. We randomly assigned participants to receive the Write Sounds intervention or a business-as-usual control. At posttest, students who received the Write Sounds intervention (n = 17) significantly outperformed the control group (n = 16) on researcher-created measures of handwriting quality and overall legibility. In study 2, three first-grade students who showed difficulty with reading, spelling, and phonemic awareness received instruction with Write Sounds. We implemented a multiple-baseline design. Results showed that Write Sounds increased participants' word reading abilities. Results of both studies suggest that Write Sounds showed promise of effectiveness. Limitations such as small sample sizes and the COVID-19 pandemic may have impacted the findings.

Keywords: **Handwriting, reading & writing connections, word-level reading & writing challenges, intervention development.**

Introduction

Reading and writing scores have shown little improvement over the past 20 years. The National Assessment of Educational Progress (NAEP) data suggest that a

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majority of students are struggling with grade-level reading and writing skills and instructional practices designed for these students may not be effective. Moreover, students with dysfluent or illegible handwriting may have delays in their writing development (Santangelo & Graham, 2016), which may lead to difficulties expressing their thoughts (Berninger, 1999; Graham et al., 2000) or using writing to improve reading (Graham & Hebert, 2010, 2011). Consequently, there is a need for change in the way educators provide literacy instruction so "all" students can be successful instead of "some" students. Thus, the purpose of this paper is to present two studies that implement and evaluate an instructional intervention (*Write Sounds*) designed to connects current research in literacy skill instruction with relevant cognitive models, to improve students' foundational literacy skills.

Writing delays can occur in isolation or co-occur with language and reading disabilities (Katusic et al., 2009). For example, students with dyslexia or word-level reading difficulties often have difficulty with both writing skills (i.e., handwriting, spelling, organization, text-generation) and reading skills (Kandel et al., 2017; Sanders et al., 2018). More specifically, they may have handwriting that is difficult to read, numerous spelling errors, and difficulty organizing their ideas (Hebert et al., 2018; Morken & Helland, 2013). This is not surprising, as reading and writing rely on related foundational literacy skills (e.g., phonological processing, phonological memory, phonemic awareness, handwriting; Berninger et al., 2002; Brooks et al., 2011; Graham & Hebert, 2011; Sanders et al., 2018).

Integration of Literacy Skills to Support Instruction

There are several literacy-focused cognitive models that delineate and operationalize the component foundational skills and processes (e.g., planning, organization, revising) necessary to be a successful reader or writer. We drew on two cognitive models, the *Simple View of Writing* and the *Interactive Dynamic Literacy Model,* in the development of this intervention.

The *Simple View of Writing* (Berninger & Amtmann, 2003) model posits that foundational transcription skills (i.e., handwriting, keyboarding, spelling) and executive function skills (i.e., attention, planning, organizing, reviewing, self-monitoring) serve as the foundation for generating written material. Moreover, these skills are constrained by working memory capacity (e.g., ability to hold information in the mind long enough to manipulate the sounds of a word or ideas in a sentence to get it written down before forgetting) such that deficits in transcription skills (e.g., inconsistent/dysfluent letter formation, inadequate spelling ability) may affect working memory functioning and lead to difficulty with text generation. This role of working memory is also posited by other theoretical models of writing (e.g., Hayes, 1996; McCutchen, 1996).

The *Interactive Dynamic Literacy Model* (Kim, 2020) expands on the *Simple View of Writing* and identifies the overlap in component skills and knowledge for reading and writing acquisition. The idea is that reading comprehension and writing composition emerge from inter-related foundational literacy skills and knowledge in addition to other related skills (e.g., oral language, content & discourse knowledge, higher cognition & regulation, socio-emotional factors). As such, these skills overlap and draw on each other during the processes of reading comprehension and written

composition. The *Interactive Dynamic Literacy Model* also acknowledges the importance of attaining a level of accuracy and automaticity in skill development to reduce the cognitive load and free up mental resources for higher process skills.

Both the *Simple View of Writing* Model and the *Interactive Dynamic Literacy Model* provide support for the development of the *Write Sounds* intervention, which focuses on using the reciprocal nature of foundational literacy skills to improve both reading and writing outcomes for students. Given the research in the field and established models, an instructional approach that integrates reading and writing skills through the implementation of reciprocal foundational skills should improve reading and writing outcomes.

A meta-analysis by Graham and colleagues (2017) provides empirical evidence to support this theory. The researchers examined the effectiveness of integrating reading and writing skills instruction (no more than 60% for either subject) with elementary students. Findings indicated that such programs improved students' reading (i.e., average weighted *ES* of 0.39) and writing (i.e., average weighted ES of 0.37). The results support Kim's theory that teaching reading together with writing has reciprocal benefits. Therefore, an intervention that integrates reading and writing instructional skills based on evidence-based practices may help teachers by teaching reading and writing skills in tandem as well as helping students with deficits in reading and writing skills. Given time constraints faced by schools and teachers, the development of efficient intervention approaches that work on both skills in tandem may also be beneficial.

Write Sounds Intervention

The *Write Sounds* intervention was developed as a foundational literacy intervention and focuses on improving handwriting, decoding, and spelling skills. *Write Sounds* includes evidence-based instructional components (e.g., explicit letter(s) instruction, letter-sound correspondence, repeated practice, and writing fluency) to teach handwriting, phonological awareness, and spelling skills embedded in word- and sentence-level tasks. This intervention builds upon existing research by providing struggling students with an instructional approach that uses the reciprocal processes of reading and writing to support the acquisition of foundational literacy skills. The intervention is designed to be delivered in small groups of two to four students. *Write Sounds* consists of 16 two-part lessons—resulting in 32 instructional sessions—delivered four days per week, in 15-20 min sessions.

The scope and sequence of the *Write Sounds* program is sequential (e.g., progressing from easier to more complex skills; see Figure 1 for sample). The first step of the program utilizes the evidence-based practice of explicit instruction to directly teach the letter formation sequence using visual cues while simultaneously verbalizing the corresponding phoneme. The second step strengthens the letter and sound correspondence with repeated practice forming the letter while verbalizing the letter sound. The final step is to practice blending and segmenting the letters and sounds to spell dictated words, phrases, and sentences. The primary outcome is students' ability to write letters of the alphabet automatically while identifying and verbalizing the corresponding phonemes. According to the *Simple View of Writing*, increasing automaticity in letter formation should reduce demands on working memory, freeing up

resources to support higher-level thinking ideation and organization (Berninger & Amtmann, 2003; Berninger & Winn, 2006).

Another important skill that should be targeted in evidence-based practice is self-regulation (e.g., monitoring your own progress and revising as needed). *Write Sounds* includes opportunities to self-monitor and self-assess during the repeated independent practice component and when writing the dictated words. The final activity of each lesson is fluency training, during which each student writes the final sentence as many times as possible in one minute, focusing on accuracy and fluency. The teacher and student calculate the number of correct letters written per minute and graph them to demonstrate progress.

Purpose of the Current Studies

This manuscript includes preliminary evidence for the *Write Sounds* program from two studies, an underpowered experiment with a control group, and a single-case, multiple-baseline design. The purpose was to identify preliminary evidence and promise for the program.

Study 1

The purpose of the first study was to evaluate the promise of the *Write Sounds* intervention in an elementary school setting for students with word-level reading and writing difficulties. Research questions addressed the utility and promise of the intervention for impacting students' proximal handwriting and spelling outcomes only, as we were unable to administer decoding measures when this study was cut short due to the Covid-19 shutdown:

1. What is the feasibility of implementation of the *Write Sounds* intervention in an elementary school setting?
2. What are impacts of the *Write Sounds* intervention on students' handwriting skills and spelling skills as compared to those in the business-as-usual (BAU) condition?

Method

We used a matched pairs experimental design to assign eligible students to the *Write Sounds* intervention or a BAU control group.

Participants & Setting

We conducted this study in a K-8 private school system located in the Plains region of the U.S. Participants included second-and third-grade students and teachers. Nine classroom teachers across three schools participated in the study. Each classroom teacher submitted a list of six students from their classroom that met the study eligibility criteria. The students were required to be (a) in their classroom, (a) struggling with handwriting legibility, (c) experiencing word-level reading or spelling difficulties, and (d) have one of the four lowest scores in their classroom on a handwriting screener (see description in Measures). Following screening, eligible students included 18 second-grade and 15 third-grade students from nine classrooms across the three schools. Demographic characteristics are reported in Table 1 by treatment.

Write Sounds Scope and Sequence						
Lesson	**Grapheme Sequence**			**Phoneme Sequence**	**Dictated Words**	**Sentence**
Pre-Testing/Mastery Check 4						
Pre-Lesson	Letter formation types: small, tall, & falling			pencil grip	Motivation Chart & Fluency Graph	Overview of lesson structure and goals of Write Sounds
1, 2	l	i	t	short (i), (l), (t)	it, lit, tilt	
3, 4	o	c	-	short (o), (c)	lot, clot, lotic	
5, 6	a	d	g	short (a), (d), (g)	got, cat, can't	got a dog
7, 8	b	p	-	(b), (p)	big, bat, plot	A big dog got it.
Mastery Check 1: b, l, o, a, p, l, c, t, d, g						
9, 10	m	u	-	(m), short (u)	mat, lamp, but /got, camp, dump	A dog got a cat!
11, 12	n	h	r	(n), (h), (r)	hand, run, punt/ mint, runt, hunt	Did a dog dig up a plant?
13, 14	j	f	-	(j), (f)	frog, flag, job/ flip, flat, jump	The rabbit can jump and run.
15, 16	s	e	er	(s), (e), (er)	spent, stump, enter/ sudden, often, number	A sudden frost got the frog jumping!

Figure 1. **Write Sounds Scope and Sequence Sample**

Table. ***Demographic and Descriptive Characteristics of Student Participants by Group***

	Experimental *(n* = 17)	Control *(n* = 16)
Demographics	*n* (%)	*n* (%)
Grade		
2nd	9 (53%)	9 (56%)
3rd	8 (47%)	7 (44%)
Gender		
Female	8 (47%)	7 (44%)
Language		
English	14 (82%)	15 (94%)
Spanish	3 (18%)	1 (6%)
Ethnicity		
Caucasian	14 (82%)	14 (87%)
Hispanic	3 (18%)	2 (13%)
Free-reduced Lunch	4 (29%)	6 (38%)
IEPs	3 (18%)	2 (13%)
Screening Measures	M(SD)	M(SD)
CTOPP-2 (Segmenting Nonwords)	79.69 (8.26)	82.50 (13.78)
THS-R (Lion)	96.29 (19.71)	91.69 (16.12)
WIAT-III (Pseudo-word Decoding)	88.25 (14.58)	95.69 (13.77)

Note. IEP = individualized education plan

The research team administered pretest measures prior to assignment. Due to the small sample size, we matched participants on two variables prior to assignment (i.e., classroom teacher and Test of Handwriting Skills-Revised Lion subtest standard score). The first two authors paired the students within the teacher's classroom (two highest and two lowest), and then one student from each pair was randomly assigned to either the *Write Sounds* intervention or a BAU control group.

There were no statistically significant differences between students on grade, gender, primary language, free & reduced lunch status, IEP status, and ethnicity. Additionally, there were no statistically significant differences between the students assigned to each group on the screener measures (CTOPP-2 Segmenting Non-word subtest and the THS-R Lion subtest) administered prior to randomization.

Measures

Our research team administered and scored the assessments after receiving four hours of training. Two raters scored each measure and resolved disagreements through discussion. We calculated interrater reliability by correlating the two raters' scores (i.e., CTOPP-2, WS Overall Legibility) or using point-by-point agreement (i.e., THS-R, WS Spelling Sounds, WS Spelling Words, WS Handwriting Letters, WS Handwriting Words).

Test of Handwriting Skills, Revised (THS-R, Lion Subtest, screening measure). THS-R is a norm-referenced assessment of handwriting and neurosensory integration skills in both manuscript and cursive (Milone, 2007). Internal consistency reliabilities range from .61-.85. The assessment consists of seven subtests. For this study, we administered the Lion subtest as a screening measure. Raters scored each of the 21 letters on a scale of 0-3 points for a total of 63 possible points (score range 0-63). Inter-rater reliability was .95.

Comprehensive Test of Phonological Processing, 2nd Edition (CTOPP-2, Segmenting Nonword Subtest, descriptive measure). The CTOPP-2 is a norm-referenced measure of phonological processing skills (Wagner et al., 2013). To evaluate each participant's ability to segment words, we administered the Segmenting Nonwords subtest, which has an alpha of .90 across all ages. We administered this subtest one-on-one. Inter-rater reliability was .84.

Researcher-Created Write Sounds Assessment. This measure included tasks at the letter and word-level of decoding and encoding and was designed as a pre and post intervention curriculum-based assessment to measure mastery of the intervention content. The Write Sounds Assessment (WS Assessment) included dictation tasks at the phoneme and sentence level. In the first task, the teacher dictated a list of the phonemes introduced up to the point of the assessment. The students wrote the grapheme that corresponds to the dictated phoneme. In the second task, the teacher dictated a sentence that incorporated words that included the letters introduced up to the point of the assessment. These words were selected from The Basic Spelling Vocabulary List (Graham et al., 1993) and were aligned with the specific letter-sound correspondences taught in the intervention. The students wrote the dictated sentence independently. Inter-rater reliability obtained was .97.

For task two, students spelled words using their best handwriting for two scores:

a) Spelling words (WS Spelling Words): Students received one point for each correctly spelled word and one point for each word containing the correct letter case (i.e., lower or upper case as appropriate) for all letters in the word for a score range of 0-24. Inter-rater reliability was .95.
b) Overall Legibility (WS Overall Legibility): Two raters scored overall legibility on a 4-point scale for quality of spacing, letter proportion, and line placement, and a 2-point scale for directionality. Each scorer totaled the four subscores to report an overall legibility score. Inter-rater reliability was .92.

Write Sounds Mastery Check 1. Four Mastery checks were developed for the program and intended to be used as formative assessments. Mastery Check 1 was administered after lesson six (one group received seven lessons due to scheduling). The mastery check included ***phoneme dictation*** and ***sentence dictation tasks***, which received a total of five scores:

a) Spelling Sounds (WS Spelling Sounds, Task 1): Raters awarded one point for each correct letter-sound correspondence. Raters accepted any grapheme that represented the target sound for a score range of 0-13. Inter-rater reliability obtained was .98.

b) Spelling Words (WS Spelling Words, Task 2): Raters awarded one point for each correctly spelled word and one point for each word containing the correct letter case for all letters in the word for a score range of 0-18. Inter-rater reliability was .92.
c) Handwriting Letters (WS Handwriting Letters, Task 1). Raters scored handwriting letters, using the scoring rules of the THS-R scoring guide. Raters rated each of the ten letters on a scale of 0-3 points for 30 possible points. Inter-rater reliability was .98.
d) Handwriting Words (WS Handwriting Words, Task 2): Raters scored using THS-R scoring guidelines. The scoring procedures were the same as described for the Lion subtest in the screening sections, and raters scored each of the 21 letters written on a scale of 0-3 points for 63 possible points. Inter-rater reliability was 0.93.
e) Overall Legibility (WS Overall Legibility, Task 2): Raters scored this on a four-point scale for the characteristics of writing quality, spacing, letter proportion, and line placement, and a two-point scale for directionality. The four subscores totaled to an overall legibility score. Inter-rater reliability was .95.

Adjusted Write Sounds Assessment (pretest Measure). Because the designed WS Assessment (Task 1) included 38 phonemes and Mastery Check 1 (Task 1) included only ten phonemes, we adjusted the pretest measures for equivalence. To do this, we truncated the WS Assessment Task 1 given at pretest to include only spelling sounds items in Mastery Check 1. We combined the separated items to create the *Write Sounds* Handwriting Letters (WS Handwriting Letters) and *Write Sounds* Spelling Sounds (WS Spelling Sounds) pretest measures to compare with WS Mastery Check 1.

Procedures

***Write Sounds* Treatment Procedures.** The first author provided the instruction for all treatment groups. Screening, pretesting, and randomization took place over two weeks. We delivered the intervention in small groups (three to four students). Groups met during the school day for four days per week through a series 15-min pull-out sessions.

BAU Control Condition. The BAU control group participated in daily activities or instruction provided by the students' grade-level teachers. The instruction varied by the grade level and school, as students were pulled for the intervention at different times during the day (e.g., centers, computer time, social studies). Classroom teachers did not observe the treatment group lessons, nor did they have access to any of the intervention materials during the study. All students received direct handwriting instruction from a traditional published program that included letter formation instruction with copying and independent practice items as part of the grade-level curriculum.

Treatment Fidelity and Dosage. We created fidelity checklists for lesson elements. Our team used the checklists to measure adherence to the required elements observed. We observed 27% of the lessons. We calculated fidelity in two ways. In the first, lesson components not taught due to time limits were not included to examine

feasibility of adherence. In the second, all lesson components were included regardless of time.

To examine dosage, we compared the number of lesson components completed to the total number of components intended for each lesson. We calculated dosage as a percentage of the total lesson components for the first ten lessons of the intervention. We included all missed lesson components in the calculation, including those missed due to student absence.

Data Analysis

We tested for differences in outcomes between the *Write Sounds* group and BAU using Analysis of Covariance (ANCOVA) for the handwriting and spelling measures. We included pretest scores as the covariate in each model to ensure that posttest differences were not due to preexisting differences between groups. ANCOVA assumptions were met for all analyses. We also computed Hedge's *g* for each posttest measure with small-sample corrections.

Results

The purpose of Study 1 was to evaluate the feasibility and effectiveness of the *Write Sounds* intervention for students with word-level reading or writing difficulties.

RQ 1 Results for Feasibility of Write Sounds Intervention

Treatment Fidelity. We first calculated the fidelity score on only lesson components time allowed for; if components were not implemented due to time, it was not due to the instructor forgetting to implement them. The instructor implemented 99.6% the *Write Sounds* intervention steps accurately. Next, we calculated the fidelity score on all designed lesson components, regardless of time constraints; 94.9% of the instructional steps were implemented. This high degree of fidelity offered evidence of usability of the intervention.

Treatment Dosage. Higher amounts of dosage illustrate a better ability to implement the intervention components in a small group setting within the 15-min time frame. For reference, we reported the student tasks for each lesson in Table 2. The instructor was able to complete most lessons within the 15-min time frame. However, for lessons 6, 8, and 10, the instructor did not complete *Fluency Training*. There were also a few sessions in which the instructor was unable to complete all the intended tasks due to classroom complications (e.g., meetings, announcements), which resulted in shorter than 15 min sessions. We calculated the dosage as a proportion of lesson components completed by the student. The total number of possible lesson components ranged between 37-46. On average, the students completed 34 tasks (range = 18-42). An average of 81% of the activities were completed across lessons, with a range of 0-100%.

Table 2. ***Description of Write Sounds Lesson Student Tasks***

New Learning Lesson Student Tasks	Cumulative Lesson Student Tasks
1) New Letter Tracing*	1) New Letter Writing*
2) New Letter Copy*	2) Writing Dictated Letters****
3) New Letter Writing*	3) Writing Dictated Words***
4) Writing Dictated Letters**	4) Writing Dictated Sentence***
5) Writing Dictated Words***	5) Sentence Fluency Writing (one-min timed practice)

Note. * = task is repeated for each new letter introduced in that lesson. ** = includes all new letters introduced in that lesson, *** = all words include letters that have been taught in this lesson or in previous lessons.

RQ 2 Impact of Write Sounds to Improve Students' Handwriting Skills

Descriptive statistics are reported for the pre- and posttest measures (see Table 3). There were no significant differences between the groups at pretest on (a) WS Handwriting Letters, (b) WS Handwriting Words, and (c) WS Overall Legibility. However, the underpowered ES for the WS Handwriting Letters pretest measure was $g = 0.21$, 95% *CI* [-0.48, 0.89], THS-R Lion screening measure ES was $g = 0.25$, 95% *CI* [-0.45, 0.94], and the WS Overall Legibility pretest measure ES was $g = 0.11$, 95% *CI* [-0.57, 0.80]. The pretest ES estimates showed potentially practically significant differences between the treatment groups. Therefore, we included the pretest measures as a covariate in all the models.

Results of the ANCOVA analyses are reported in Table 3. The analyses indicated a statistically significant effect of treatment on all three handwriting outcomes, WS Handwriting Letters ($F = 4.97$, $p = .033$), WS Handwriting Words ($F = 7.09$, $p = .012$), and WS Overall Legibility ($F = 6.49$, $p = .016$). Students in *Write Sounds* scored, on average, 3.34 points higher on the WS Handwriting Letters measure [$g = 0.76$, 95% *CI* (0.05, 1.47)], 6.85 points higher on the WS Handwriting Words measure [$g = 0.91$, 95% *CI* (0.19, 1.63), and 1.29 points higher on the WS Overall Legibility measure [$g = 0.86$, 95% *CI* (0.15, 1.58)]. These results are promising, especially considering that the intervention was only partially implemented. Eta-squared values ranged from .05 to .06 for spelling measures and .14 to .19 for reading measures, suggesting that the proportion of variance associated with the intervention treatment was larger for reading than for spelling.

Table 3. ***Descriptive Statistics and Analysis of Covariance in Handwriting and Spelling Measures***

Measure	Treatment		Control		*F*	η^2
	M	SD	M	SD		
WS HW Letters Pre	18.35	5.49	17.19	5.54		
WS HW Letters Post	24.65	3.39	21.31	4.89	4.97	.14
WS HW Words Post	49.29	5.84	42.44	8.00	7.09	.19
WS Legibility Pre	9.35	1.58	9.19	1.17		
WS Legibility Post	10.29	1.61	9.00	1.32	6.49	.18
WS Spelling Sounds Pre	9.94	1.14	9.88	1.20		
WS Spelling Sounds Post	9.88	0.33	9.62	0.80	1.44	.05
WS Spelling Words Pre	19.00	2.62	19.06	2.49		
WS Spelling Words Post	16.76	1.79	15.88	1.96	1.91	.06

Note. Treatment $n = 17$, Control $n = 16$; WS = *Write Sounds* Researcher-Created Measure; HW = Handwriting; Leg = Legibility; η^2 = eta-squared.

RQ 3 Impact of Write Sounds to Improve Students' Spelling Skills

Descriptive statistics are reported for the spelling pre- and posttest measures in Table 3. We calculated the pretest ESs for each of the spelling measures to determine whether there were potential practically significant differences between the groups that should be controlled for in the analyses. The ESs were $g = 0.05$, 95% *CI* [-0.63, 0.73] and $g = -0.02$, 95% *CI* [-0.71, 0.66] for WS Spelling Sounds and WS Spelling Words, respectively. Although the ESs were negligible, we included them in the models for consistency. Results for the ANCOVA are reported in Table 3. Students in the treatment condition did not statistically significantly out-perform BAU on the WS Spelling Sounds ($F = 1.54$, $p = .225$) or WS Spelling Words ($F = 1.91$, $p = .177$) measures. Although there were no statistically significant differences, students in the *Write Sounds* treatment condition scored, on average, 0.26 of a point higher on the WS Spelling Sounds measure [$g = 0.41$ *ns*, *95% CI* (-0.28, 1.11)], and 0.88 of a point higher on the WS Spelling Words measure [$g = 0.47$ *ns*, 95% *CI* (-0.22, 1.16)] than students in the BAU control group. Despite non-statistically significant findings, the moderate ESs are promising, especially considering that the study was underpowered and not fully implemented.

Study 2

The purpose of study 2 was to examine the effects of the *Write Sounds* intervention for students with reading and working memory difficulties. The two research questions were:

1. Is there a functional relation between the *Write Sounds* intervention and word reading skills for first-grade children with working memory difficulties?

2. Is there a functional relation between the *Write Sounds* intervention and spelling skills for first-grade children with working memory difficulties?

Method

We utilized a multiple-baseline across participants design to examine the effects of the *Write Sounds* intervention on word reading and spelling skills.

Participants

To be eligible for this study, participants had to: (a) be enrolled in first grade, (b) score below the 25th percentile in at least one of four subtests from the WIAT-III (i.e., alphabet fluency, word reading, pseudoword decoding, and spelling), and (c) show working memory difficulties by scoring below the 25th percentile in the subtests Memory for Sentences and Last Word from the Stanford Binet Intelligence Scales (Fifth Edition).

Three participants were recruited from a University Reading Center. All the participants were white, English-speaking, and in first grade. Pseudonyms were used for all participants (Jared, David, & Paige). Table 4 includes each participant's scores for the screening measures.

Table 4. ***Description of Inclusion Criteria Percentile Scores for each Participant***

	Age	Gender	Alphabet Fluency	Spelling	Word Reading	Pseudoword decoding	Working Memory
Jared	8y 4m	M	79th	14th	58th	73rd	5th
David	8y 5m	M	75th	14th	18th	32nd	16th
Paige	7y 6m	F	53rd	14th	7th	4th	5th

Setting

All assessment and instructional sessions took place virtually over Zoom due to state and local Covid-19 restrictions that were in place at the time of the study. We used a Zoom link and utilized the waiting room feature to allow only one participant in the meeting at a time. We used a neutral background in a quiet room to conduct the sessions. Jared and David always had a parent who sat beside them during the meetings to ensure they were attentive during the session. Jared and David each met in a quiet room with a desktop computer. Paige met in her kitchen or outside with a tablet or phone.

Materials

The participants and third author both used a computer device with reliable internet. We sent participants a printed version of the *Write Sounds* student response

book, fluency graph, self-progress monitoring chart, initial screening measure materials, notebook paper, writing utensils, and stickers. We created PowerPoint presentations for the lessons and measures.

Screening Measures

WIAT-III Subtest: Alphabet Fluency. Participants wrote as many alphabet letters as they could for 30 seconds. We totaled the number of legible letters to get the participant's raw score and then converted the score to a percentile. The Spearman Brown split-half correlation for the alphabet fluency subtest was .69 (Breaux, 2010).

WIAT-III Subtest: Spelling. Participants spelled words that became progressively more difficult. After four consecutive spelling errors, the measure was discontinued. We totaled the number of correctly spelled words, which was converted to a percentile. The Spearman-Brown split-half correlation for the spelling subtest was .87 (Breaux, 2010).

WIAT-III Subtest: Word Reading. Participants read words displayed on the computer screen. We created a PowerPoint of the words in the test so that it could be administered over Zoom. We totaled the number of words read correctly to get the participant's raw score, which was converted to a percentile. The Spearman-Brown split-half correlation for the word reading subtest was .98 (Breaux, 2010).

WIAT-III Subtest: Pseudoword Decoding. For pseudoword decoding, we created a PowerPoint for the words on the measure and participants read nonsense words displayed on the computer. We totaled the number of words decoded correctly for a raw score and converted it to a percentile. The Spearman Brown split-half correlation for the pseudoword decoding subtest was .97 (Breaux, 2010).

Stanford Binet Intelligence Scales (Fifth Edition): Memory for Sentences and Last Word. We administered the Memory for Sentences and Last Word subtests to measure participants' working memory abilities. For the Memory for Sentences subtest, we dictated a sentence, and the participant repeated the sentence. They received a point for each correct response. For the Last Word subtest, we asked each participant three 'yes' or 'no' questions. After the third question we asked the participant to recite the last word from each question. The participant received a point for each word they could remember correctly and two points if they could recite them in the correct order.

Dependent Measures

Word reading was the primary dependent variable used to decide when each participant moved from baseline to the intervention phase. We used the results from the screening measure results to differentiate each participant's starting point of instruction. Jared and David started instruction at the advanced level of the intervention, which focused on long vowel sounds. Paige started instruction at the beginning and focused on the letters of the alphabet and short vowel sounds. As a result, two separate word lists were created for the assessment, with one list aligned with the advanced curriculum and one aligned with the beginner curriculum, allowing us to measure each participant's growth according to instruction.

Word Reading. To create word reading sets, we randomly selected words from the respective word list to measure each participant's word reading abilities. Twenty reading sets were created for the beginning and advanced curriculum, with 22 words in each set. For the advanced curriculum, each set included the long vowels A (spelled a-e and ay), E (spelled e-e and ee), I (spelled i-e and y), O (spelled o-e and oa), and U (spelled u-e and oo). Each set included two words for each vowel spelling and two randomly selected short vowel words, for a total of 22 words in a set. All words were one-syllable, except for "athlete" and "compete," which were included as practice in Write Sounds. Multiple words in each list had the digraphs sh, wh, th, and ch, which were included in the intervention. All words were 3-6 letters long. Among the words in the list, 47% of the words were five letters long, 47% were four letters long, 5% were three letters long, and 1% were six letters long.

For the beginner curriculum, each set included words with the short vowels A, E, I, O, U. Each set contained two words from the short vowel CVC list and two from the CVCC/CCVC list for a total of 20 words. Two more CVC words were randomly selected for a total of 22 one-syllable words in each set.

To administer the word reading measure, we used PowerPoint slides with one word on each slide for the participant to read. When the participant read the word correctly, we marked a "yes" by the word on the recording form. If the participant said the word incorrectly or stated they did not know, we marked it with a "no." We counted all the words read correctly and calculated a percentage.

Spelling. To measure each participant's spelling abilities, we randomly selected words from the word reading lists to create the spelling sets. Thirty spelling sets were created for both the beginning and advanced curriculum, with 12 words in each set. For the advanced curriculum, we randomly selected one word from each long vowel spelling list for a total of 10 words. Then, we randomly selected two words from any short vowel list for a total of 12 words in each set. For the beginner curriculum, we randomly selected two words from each short vowel list (A, E, I, O, U) for a total of ten words. Then, we randomly selected two words from the CVCC/CCVC word lists for a total of 12 words in each set.

We dictated the word, provided a sentence with the word in it, and dictated the word again. The parent then took a picture of the spelling test to send to the researcher, or the participant held up the test, and the researcher would take a screenshot of it. Then we totaled the words spelled correctly and calculated a percentage.

Data Analysis

Data for all participants were analyzed visually. We evaluated baseline data points for stability and compared intervention data points for changes in trend, level, and variability. We also calculated Tau-U effect sizes, which show the proportion of intervention phase data that improved from baseline, to supplement the visual data (Parker et al., 2011). The Tau-U index ranges between -1 to 1, with < 0.20 representing a small effect, 0.20 to 0.59 a moderate effect, 0.60 to 0.80 a large effect, and > 0.80 a very large effect (Vannest & Ninci, 2015).

Procedures

Participants engaged in at least seven, 10-minute baseline sessions. Due to scheduling, we met with Jared and David twice a week for 40 minutes instead of 3 days a week for 20 minutes. Jared and David met for 11 intervention sessions. Each intervention session included two Write Sounds lessons that ended with a reading and spelling measure. Paige met two days a week for the baseline and intervention phases. In the intervention phase, she completed one lesson each session for a total of eight. The third author conducted all the sessions.

Baseline. The baseline condition included the reading and spelling tests. After each test, we provided general verbal praise to the participant. The number of baseline sessions varied by participant depending on when they demonstrated a stable baseline.

Write Sounds Intervention Sessions. The Write Sounds intervention was described in Study 1. However, Jared and David started in the more advanced lessons, focused on digraphs and long vowels. In contrast, Paige started at the beginning of the curriculum, which focused on the alphabet letters and short vowels. For the advanced lessons, each lesson 'set' introduced two graphemes. The first lesson introduced the graphemes, the second lesson reviewed the new graphemes, and the third lesson was a cumulative review. For the beginner curriculum, each lesson set introduced 2-3 graphemes. Each lesson set included two lessons, the first lesson introduced the new graphemes, and the second lesson was a cumulative review.

Maintenance. The maintenance condition included up to five reading and spelling tests to measure if participants maintained what they learned from Write Sounds. We gave verbal praise after each participant completed the tests.

Treatment Integrity/Fidelity

We completed training for the instruction of Write Sounds and a booster session for treatment fidelity at the beginning of the study. We measured treatment fidelity on 25% of the intervention sessions. We used a fidelity checklist to ensure we adhered to all lesson components. Each participant's environment varied, which impacted instruction. For Jared and David, the intervention was implemented at a high degree of fidelity, with 99% of the instructional steps completed correctly. For Paige, 79% of the instructional steps were completed correctly. It is important to note that low fidelity scores for Paige were based on a lack of compliance from the student, rather than missed components. For example, a component on the checklist that was frequently missed for Paige was "student repeats high-frequency word." The instructor prompted the student to repeat the word consistently, but the student did not comply, resulting in lower fidelity scores.

Results

Word Reading Results

Word reading was the primary outcome measure used to make decisions for moving each participant from baseline to the treatment phase. Figure 2 graphically represents each participant's word reading results. An overall Tau-U was calculated for the word reading measure and resulted in a Tau-U of 0.92 (SD = 0.15).

Jared. Jared was the first participant to receive instruction. Jared's baseline showed an increase in trend for the first four data points and then decreased slightly for three data points. We collected 7 data points before Jared started the intervention. Jared completed all 22 lessons in the advanced curriculum. He showed a gradual increase in trend until he consistently hit the top score of 100% at lesson 18 for the rest of the intervention. During maintenance, his scores varied between 95% and 100% (SD = 2.89). Overall, his reading scores increased from baseline (M = 65.57) to intervention (M = 84.14), and then stayed consistently high in the maintenance phase (M = 97.50).

David. David started instruction after Jared received eight intervention lessons. David's reading baseline was variable (SD = 12.79) and showed an upward trend for the nine data points collected. Once he started the intervention, his scores increased past baseline, indicating a slight change in level. He also showed a gradual increase in trend throughout the intervention phase. David completed all 22 lessons in the advanced curriculum. During maintenance, he consistently scored 100% on all but one of the data points. David showed an increase in reading scores from baseline (M = 32.78) to intervention (M = 73.95) and stayed consistent with his increased scores in the maintenance phase (M = 99).

Paige. Paige received instruction after David completed eight intervention lessons. She completed nine baseline assessments before she began instruction. Her baseline was fairly stable (SD = 5.99). Unfortunately, due to time constraints, Paige only completed eight intervention lessons. Once she started instruction, Paige's word reading data showed a change in level compared to baseline, indicating the instruction increased her word reading abilities. She also showed an increase in trend from baseline (M = 38.38) to intervention (M = 65.50).

Summary of Word Reading Results. Jared's and David's baseline data were variable and had a slight upward trend, while Paige's baseline data was more stable. Each participant was still in school at the start of the intervention, which may explain the slightly increasing baseline trend displayed in the data. For the intervention phase, David and Paige showed an increase in scores once they started the intervention, demonstrating a change in level. Jared showed an increase in trend, although the variability in his data points continued throughout the study. Jared also scored higher in his baseline scores (M = 65.57) than David (M = 32.79) or Paige (M = 38.38), indicating that he may have had some skills taught in the intervention. This may have reduced the amount of growth possible for any given session. Jared and David also maintained their high scores after completing the intervention.

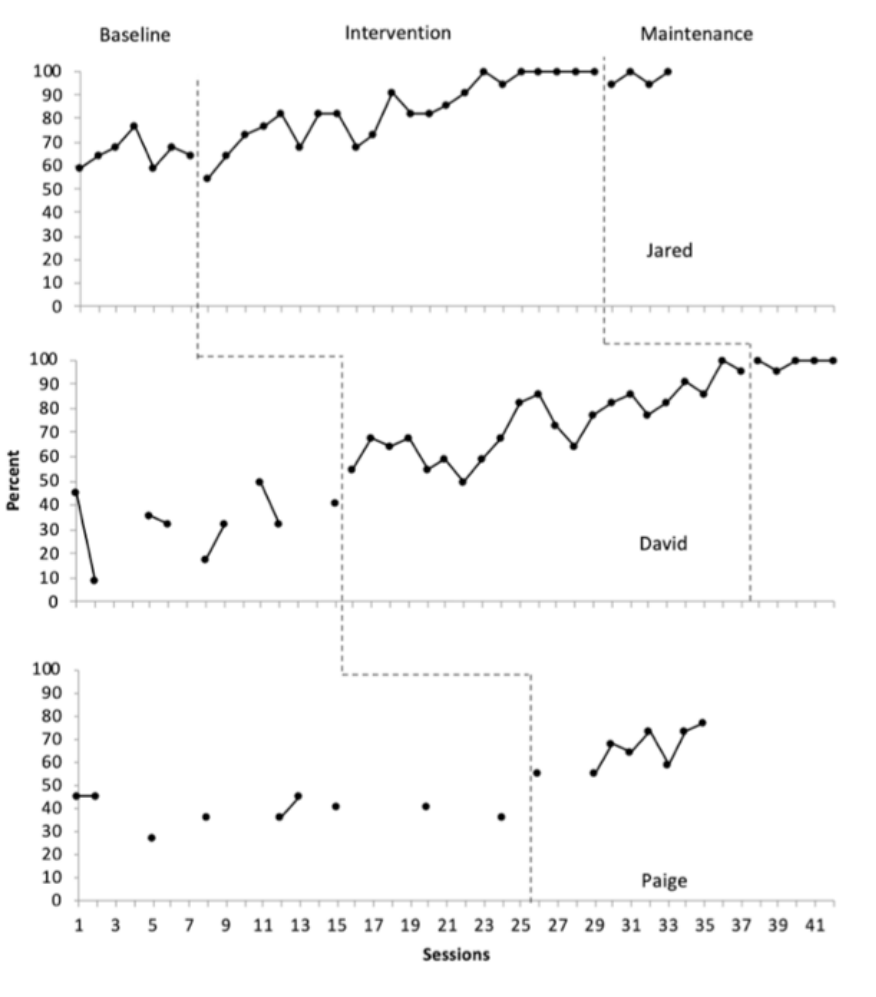

Figure 2. **Word Reading Percentage Scores for each Participant**

Spelling Results

Spelling was the secondary measure in the study; it was not used to make phase change decisions. Figure 3 graphically represents each participant's spelling results. An overall Tau-U was calculated for the spelling measure and resulted in a Tau-U of 0.58 (SD = 0.16).

Jared. Jared's baseline spelling scores were variable for the seven data points collected (*SD* = 11.83) and demonstrated a trend increase. He showed a small gradual increase in scores throughout the intervention, but many of his intervention scores were consistent with baseline. His maintenance phase scores also showed some variability (*SD* = 10.72). He showed a slight increase when he started maintenance, but his scores gradually decreased for the remainder of the phase. The maintenance

phase scores averaged higher ($M = 70.75$) than intervention ($M = 51.55$) and baseline scores ($M = 29.71$).

David. David's spelling scores were slightly variable in baseline ($SD = 7.05$). During the intervention phase, his scores showed small increases ($SD = 13.63$) but stayed reasonably consistent with his baseline scores. His score increased substantively at lesson 19 and decreased slightly as he finished the intervention. His spelling scores were also variable during the maintenance phase ($SD = 9.31$). Overall, he showed an increase in spelling from baseline ($M = 15$) to intervention ($M = 23.14$). His scores did not increase in the maintenance phase but stayed consistent with the final intervention data point.

Paige. Paige completed eight spelling assessments in baseline before beginning instruction. Her baseline scores were reasonably consistent ($SD = 7.13$) but did show a slight increase in trend. There was a slight change in level as she began the intervention. The environment on Paige's Zoom sessions was considerably distracting, which may have contributed to her low scores after lesson five in the intervention phase. Towards the end of the intervention, Paige had less time available to be in the intervention, resulting in less time to complete the spelling measure. It is difficult to determine whether Paige's scores changed due to the intervention because she had so few data points.

Summary of Spelling Results. Overall, each participant's spelling scores were more variable than their word reading data. Paige demonstrated a change in level from baseline to the intervention phase, except for the last data point. However, she did not have adequate data to determine if the intervention affected her scores. Jared's spelling scores do not demonstrate a change in level from his baseline scores until lesson 15. The same goes for David, as he did not demonstrate a change in level until lesson 19. Because of these reasons, we cannot directly attribute the growth in spelling to the intervention.

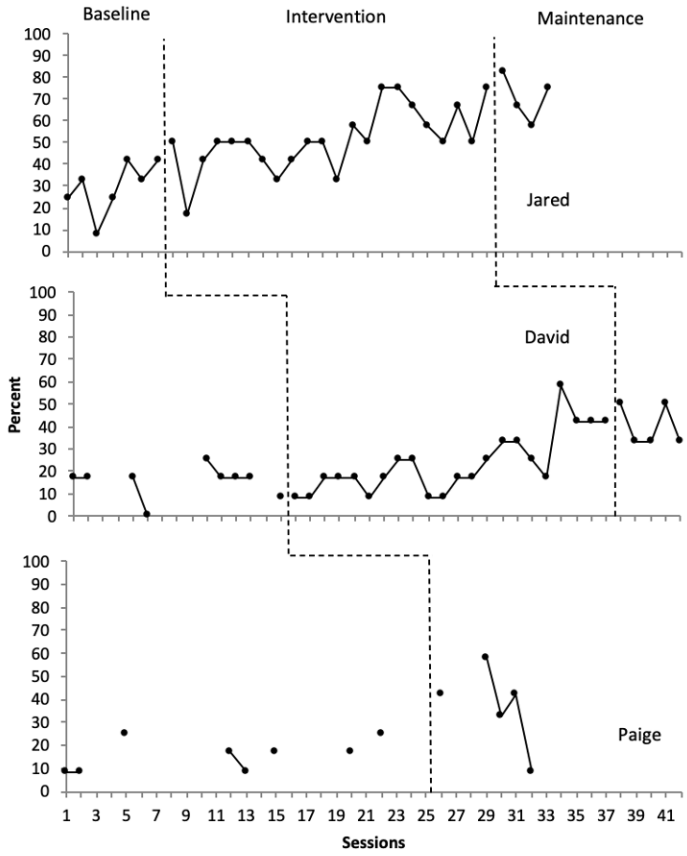

Figure 3. **Spelling Percentage Scores for each Participant**

Discussion

The *Write Sounds* intervention was designed to provide reciprocal benefits by teaching phonics and handwriting in an integrated approach for students with word-level reading and handwriting difficulties (Ehri, 2005; Graham et al., 2017). What sets this program apart from other programs is reading and writing are taught at the same time using evidence-based practices, decreasing the overall amount of instructional time needed for mastery. The current studies were designed to determine the feasibility and promise of the *Write Sounds* intervention.

Feasibility of implementing the intervention was examined in Study 1. Integrating reading and writing skills has the potential to improve efficiency of instruction and capitalize on the reciprocal development of shared skills. The intervention instructor implemented the lessons with a high degree of fidelity and dosage within a 15-minute time frame.

The dosage results of Study 1 were less promising, with 81% of the activities completed. In addition, considering that the intervention was implemented by its developer, it may be difficult for another instructor to complete the activities in the allotted time. For example, the fluency training component was not delivered to any group due to time constraints. This component was developed to increase letter automaticity and transfer the handwriting skills to traditional notebook paper, so it is crucial for struggling students. Therefore, it appears that the 15-min time allotted for the cumulative review lessons is insufficient.

Promise of Write Sounds

Results of both studies indicate some promise for the *Write Sounds* interventions impact on both writing and word reading skills. For writing, the ANCOVA analyses in Study 1 indicated the intervention had statistically significant effects on all handwriting outcomes, despite the small sample, moderate to large effects on researcher-created proximal measures of students' handwriting accuracy for writing individual letters (*ES* = 0.76), writing words (*ES* = 0.91), and overall legibility (*ES* = 0.86). Study 2 did not examine handwriting. These positive results for handwriting are promising, considering that the students did not complete the intervention. Students in the treatment group made small overall average gains, ranging from writing a little over one letter to around seven letters more on the measures.

These handwriting results were comparable to related prior research (e.g., Graham et al., 2000; Denton et al., 2006). Although the *Write Sounds* treatment group only completed six to seven lessons prior to the WS Mastery Check (used as the posttest due to the COVID-19 shutdown), the gains on the *Write Sounds* handwriting measures ranged from 1.29 to 6.85 letters as compared to the 4.63 to 10.04 letters found in the Denton et al. (2006) and Graham et al. (2000) studies. The results are promising, considering the *Write Sounds* treatment group received around 77 to 88 percent fewer instructional minutes than the cited interventions, which included 400 and 600 mins of instruction, respectively.

Despite the promising results for handwriting, there were no conclusive findings for spelling. The expectation was that an increase in handwriting accuracy would reduce students' working memory load, freeing up working memory resources to spell words more successfully, based on the Simple View of Writing (Berninger & Amtmann, 2003). Despite having small to moderate ESs for spelling measures in Study 1 and increases in spelling over time in Study 2, there were no statistically significant findings or functional relations identified for spelling across the studies. That said, students did not complete the intervention in Study 1, and spelling was only a secondary focus of Study 2. It may be that spelling requires more instructional time or a more targeted focus. That is, there may be a latency of learning in spelling following a phonics intervention, as spelling sometimes lags behind phonics. Interestingly, we saw some fairly large jumps in spelling scores for Jared and David for spelling later in the intervention, that might be indicative of this latency.

Additionally, only 24% of the lessons were completed in study 1, which is critical when considering the sequential and cumulative nature of the intervention, with the more advanced concepts introduced in the later lessons. Many students had deficits in the advanced concepts (i.e., long-vowel sounds, digraphs, diphthongs)

that are not taught until lesson 19 of the *Write Sounds* intervention. Therefore, the students received handwriting instruction in most of the letters but did not receive the related phonics instruction of the more complex graphemes (e.g., e-e, ay, sh), which could have impacted the students' gains in the spelling measures. Study 2 was also not well designed to identify spelling gains. Participants did not receive full instruction on the spelling patterns in Study 2 that appeared on the repeated spelling measures until lessons 15-19. In other words, they were not taught spelling skills fast enough to lead to immediate changes in level for spelling, which impacted the results. Finally, the students also did not receive the designed amount of repeated practice in study 1, which is a critical component for developing automaticity (Kubina & Morrison, 2000; Logan, 1997).

Unfortunately, the COVID-19 pandemic cut short Study 1 before impacts on word-reading skills could be assessed. However, Study 2 did show some promise for improving word-reading skills, with clear positive results of the intervention for two out of the three participants, and improvements in the third student that could not be as clearly attributed to the intervention. Although this is not conclusive, the promising findings align with findings from a meta-analysis conducted by Graham & Hebert (2011) that found an ES of 0.68 for the impacts of spelling instruction on word reading.

Limitations

The COVID-19 pandemic forced the closure of all schools and suspension of all in-person research during Study 1, which is an obvious limitation. Therefore, the treatment group completed only 24% of the intervention (i.e., 6 to 7 lessons) prior to the WS Mastery Check, and it's impossible to know whether the participants would have benefited from the more complex concepts in the later lessons that were not completed. Similarly, the full intervention was not completely implemented in Study 2, which was also implemented over Zoom later in the COVID-19 pandemic, although students were in school more regularly and may have been familiar with virtual instruction to some degree. The impacts of the intervention may have been dampened. It is also worthwhile to mention that the presence of an adult could have affected the fidelity of the intervention for the students in Study 2.

Next, the intervention was implemented with a single instructor for all groups in both studies. The instructor in Study 1 had over 15 years of experience teaching children with learning disabilities and was also a developer of the intervention. Therefore, there are potential teacher effects. Instruction in study 2 was delivered by a graduate student who was directly trained by the first author and developer of the intervention.

Additionally, the results of these studies are limited due to the size and homogeneity of the samples. All the participants were recruited from schools in the Midwest. Thus, the learning environment, curriculum, and demographic characteristics of the students and teachers may not generalize to other more diverse settings. For example, with a larger sample, researchers may be able to examine possible grade-level effects.

Suggestions for Future Research

Based on these findings and alignment with prior research, the combined results of these studies seem to suggest that *Write Sounds* has promise for improving handwriting and word reading, with some reasons for optimism for spelling outcomes. Combined with the results on feasibility outcomes in Study 1 and the online delivery of instruction for Study 2, further study of the *Write Sounds* intervention is warranted. Future research should focus on full implementation of all of the intervention components.

Another important topic is the role of working memory. Each participant in Study 2 scored below the 25th percentile for working memory. As discussed in the introduction, working memory plays an important role in the development of reading and writing (Kim, 2017; Kim & Park, 2019). The current study examined reading and writing outcomes for the *Write Sounds* intervention, a balanced reading and writing intervention, with participants who had working memory difficulties. A potential drawback of implementing balanced interventions with students who have working memory difficulties is that it may be too difficult to hold the information required for both reading and writing in their minds. On the other hand, a benefit of balanced interventions may be that it requires students to hold less information in their mind as they are learning both reading and writing. Overall, we found the intervention to be moderately effective in increasing participants' word-reading skills, which may justify a further examination of the benefits of balanced reading and writing programs for students with working memory difficulties. Future research should incorporate further study of the impacts of working memory on students' growth in this intervention.

Conclusion and Recommendations

Although the results from both studies (Shanahan Bazis, 2020; Wambold, 2021) are promising, neither study was completed as intended. For example, research questions regarding students' growth in handwriting fluency were not answered in either study. Yet, in the first study, researchers were able to assess handwriting accuracy in isolation and context with statistically significant results. Participants in both studies increased their spelling scores. In the first study, the students in the *Write Sounds* intervention group outperformed the BAU control group, although not significantly. While students in the second study showed an increase in spelling towards the end of the intervention. Unfortunately, since participants' baselines were more variable for the spelling outcome, we cannot attribute spelling increases to the intervention, and more research is warranted. A pre-test and post-test measure may be more suitable for measuring spelling with this intervention.

The *Write Sounds* intervention seemed to be moderately related to increases in participants' word-reading skills in the second study, , strengthening the evidence that reading-through-writing and writing-through-reading approaches can be beneficial (Graham & Hebert, 2010). Furthermore, data gathered in the first study on the usability and feasibility of the intervention provide information to guide future iterations of the *Write Sounds* intervention. Overall, the results of the studies implementing the *Write Sounds* program do not provide strong evidence to confirm or contradict the idea that an intervention that integrates reading and writing instruc-

tion will improve both reading and writing outcome measures for students. Rather, the results provide support for further investigation of the *Write Sounds* program in a study that is implemented with fidelity.

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