Effects of Data-Based Writing Instruction on the Reading Outcomes of Elementary Students with Writing Difficulties

A Dissertation

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Abstract

Difficulties in writing can emerge as early as preschool, and often coincide with developing difficulties in reading (Berninger et al., 1997; Graham & Santangelo, 2014; Graham et al., 2020), as reading and writing are fundamentally connected skills (e.g., Fitzgerald & Shanahan, 2000). Writing instruction in general has had positive effects on reading outcomes of students across grade levels (Graham & Hebert, 2011). However, more research is needed to examine whether writing instruction can support the reading skills of elementary students with writing difficulties (Graham, 2020). Data-based instruction (DBI) in writing, which includes research-based writing instruction activities, frequent progress monitoring using curriculum-based measures (CBM) in writing, and data-based decision-making (DBDM) to individualize instruction, has been found to have promising effects on the writing outcomes of students with significant writing difficulties (McMaster et al., 2020), and may similarly support reading. Thus, the purpose of this dissertation was to examine whether DBI in writing can play a positive role in the foundational reading development of elementary students who benefit from intensive writing support.

The current study used data from one cohort of participants in a multi-cohort randomized control trial evaluating the effects of DBI professional development on teachers' use of DBI in writing and students' writing outcomes. Participants in this study included 42 teachers (19 treatment, 23 control) and their 105 students with significant writing difficulties in Grades 1 to 5 (46 treatment, 59 control). Treatment teachers implemented writing instruction, collected CBM-writing data, and engaged in DBDM with fidelity while receiving ongoing, collaborative support via learning modules and twice-monthly coaching. Treatment students received an average of 37.3 hours of DBI in writing across 20 weeks of study participation. Depending on teachers' assessment of students' needs, teachers typically targeted spelling, but also taught handwriting and/or text

generation. Pretest correlations indicated that the two reading outcomes, letter sound knowledge and decodable word reading, as measured by FastBridge Letter Sounds correct letter sounds per minute (LS CLSPM) and Decodable Words correct words per minute (DW CWPM), were associated with writing skills spanning from spelling to written expression. Hierarchical linear models controlling for the effect of teacher intercept indicated that DBI in writing did not have a positive effect on LS CLSPM. DBI did, however, have a significant positive effect on log-transformed DW CWPM after controlling for log-transformed pretest scores, meaning that DBI in writing had the strongest effect on the reading of students with higher initial decoding skills. Future research should investigate the effects of more specific letter sound writing interventions on letter sound knowledge and examine whether and why Matthew effects (Stanovich, 1986) may occur in DBI. Implications for teachers' integration of reading and writing interventions as well as next steps for system-level writing assessment are discussed.

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Chapter 1: Introduction

Beginning in elementary grades, students discover new ideas by reading text, and they deepen their understanding of these ideas by writing about them. Unfortunately, many students in the United States struggle with both skills, and in particular, writing. Writing is the act of composing meaningful text to communicate within a shared language system (e.g., Graham & Hebert, 2011; Shanahan, 2016), and difficulties in writing skills can emerge as early as preschool. Writing difficulties also often coincide with developing difficulties in reading (Berninger et al., 1997; Graham & Santangelo, 2014; Graham et al., 2020), as reading and writing are fundamentally connected skills (e.g., Fitzgerald & Shanahan, 2000). Given that reading and writing are connected, interventions in one domain may remediate skills in both domains. Although a previous research synthesis by Graham and Hebert (2011) found that writing instruction in general can have a positive effect on the reading skills of students across grade and ability levels, more research investigating the effects of writing interventions on the reading outcomes of young students experiencing difficulty with literacy skills is needed. If writing interventions lead to increased reading outcomes for these students, this finding would reinforce the importance of targeting writing skills in literacy interventions.

The purpose of this dissertation is to examine the effect of an intensive writing intervention on the reading outcomes of elementary students with literacy difficulties. My central hypothesis is that the intervention will have a small but positive effect on reading outcomes, but this effect will vary depending on students' level of reading difficulty and grade. This hypothesis is informed by empirical evidence indicating an overall positive effect of writing instruction on reading outcomes (e.g., Graham & Hebert, 2011; Tierney & Pierson, 1983), and that students with writing difficulties benefit from data-based instruction (DBI; Deno & Mirkin, 1977;

McMaster et al., 2020) and interventions delivered at a high dosage in a small group (e.g., Graham & Santangelo, 2014; Wanzek et al., 2016). I anticipate that findings from this dissertation may contribute meaningfully to the design of efficient, effective interventions to support early reading and writing development.

The Importance and Challenge of Reading and Writing

The importance of both reading and writing for children's academic and postsecondary success cannot be overstated. Beginning in elementary grades, students read and write to develop and understand new ideas (Graham & Perin, 2007; Graham et al., 2020). Reading and writing are also essential skills for students' future employment, serving the purposes of sharing and acquiring information, as well as communicating in society (Greene, 2000; National Commission on Writing, 2003, 2004).

Unfortunately, many students in the United States experience difficulties in reading, and even more acute difficulties in writing. According to the recent National Assessment of Educational Progress (NAEP), only 32% of fourth graders, and 11% of students with disabilities, scored at or above proficient in reading (NCES, 2022). Additionally, 27% of 8th graders, and 5% of 8th graders with disabilities, were performing at or above proficient in writing at the last time these data were collected (NCES, 2012). These reading and writing difficulties often co-occur in grades as early as preschool (Thomas et al., 2020). Additionally, rates of comorbidity remain stable across elementary grade levels (Costa et al., 2016), and continue through students' schooling, as 30% to 75% of school-age children with writing difficulties are estimated to have comorbid reading difficulties (Costa et al., 2016; Dickerson Mayes & Calhoun, 2007; Katusic et al., 2009). Together, these findings suggest that reading and writing difficulties may be developmentally connected.

Connections Between Reading and Writing Development and Difficulty

To understand how connected reading-writing difficulties can emerge for elementary students, it is important to first consider how reading and writing have been theorized to develop alongside one another. One initial theory was the *shared knowledge* view, which posits that reading and writing both rely on common knowledge and processes (Fitzgerald & Shanahan, 2000; Shanahan, 1987; Shanahan, 2016). In the shared knowledge view, learners draw on four proposed shared sources of knowledge: meta-knowledge (e.g., knowledge of meaning-making processes in both reading and writing), domain knowledge, knowledge of text attributes, and procedural knowledge (e.g., how to create and use meaningful text; Fitzgerald & Shanahan, 2000).

Another more recent theory of reading-writing connection is the *interactive dynamic literacy model* (IDLM; Kim, 2020). Similar to the shared knowledge view, this model proposes that reading and writing emerge from multiple shared sources of knowledge. However, the IDLM further specifies that reading and writing develop from shared cognitive and linguistic knowledge and skills, informed by Virginia Berninger's functional system of language by eye (reading) and language by hand (writing; Berninger & Abbott, 2010; Berninger et al., 1996; Berninger et al., 1997), as well as the *simple view of reading* (Gough & Tunmer, 1986) and the *not-so-simple view of writing* (Berninger & Winn, 2006; Berninger et al., 2002a).

The IDLM synthesizes these theories to establish one, unified reading-writing knowledge and skill hierarchy. Foundational to the IDLM hierarchy are (a) domain-general cognition and executive function (e.g., working memory, attentional control). These foundational abilities facilitate the development of sublexical skills, which are (b) phonological, morphological, and orthographic knowledge, as well as (c) handwriting or typing. These sublexical skills are needed

for lexical skills, which include (d) vocabulary as well as (e) word reading and spelling. Lexical-level skills are built upon to develop sentence-level skills, which include (f) syntactic knowledge, (g) oral sentence comprehension and production, and (h) written sentence comprehension and production. Sentence-level skills inform the development of discourse-level skills, which are (i) listening comprehension and oral production, as well as (j) reading comprehension and written composition. Lexical, sentence, and discourse-level skill development are supported by (k) higher-order cognition and regulation (e.g., inference, goal setting), (l) content and domain knowledge, and finally, (m) social-emotional states (e.g., motivation, engagement).

The IDLM posits that reading-writing relations are *hierarchical* and *interactive* in nature, meaning that downstream effects from lower- to higher-order skills on this hierarchy occur, and changes in one skill can influence changes in another skill. Clemens et al. (2014) found that early kindergarten spelling skills predicted first grade phonological awareness, decoding, and word reading. Conversely, phonological, orthographic, and morphological skills have been found to jointly predict spelling difficulties in Grades 1 to 5 (Garcia et al., 2010). Additionally, students with word reading difficulties in particular perform consistently lower on measures of handwriting and spelling (Barth et al., 2010; Bishop et al., 2009; Carroll & Breadmore, 2018; Curtin et al., 2001; Duff & Hulme, 2012; Kim et al., 2013; Komesidou, 2018; Sumner et al., 2016), as well as written output and writing quality (Sumner et al., 2016). These relations support the hypothesis that reading-writing difficulties develop interdependently.

The IDLM also theorizes that reading-writing skill relations are *dynamic*, meaning that relations between skills change across developmental phases. For beginning readers and writers, relations are strongest at the lexical level, and moderate at the sentence and discourse level (Ahmed et al., 2014; Shanahan, 1984). For more advanced readers and writers, typically in upper

elementary grades, lexical level skills become more automatized, and relationships are stronger between text comprehension and composition (Berninger et al., 2002b; Shanahan, 1984). Upper elementary students with reading-writing difficulties are often in the emergent phases of reading development (Ehri et al., 1997). As a result, the negative effect of reading difficulties on handwriting and spelling is similar for lower and upper elementary students (Barth et al., 2010; Carroll & Breadmore, 2018; Curtin et al., 2001; Duff & Hulme, 2012; Kim et al., 2013; Komesidou, 2018; Sumner et al., 2014; Thomas et al., 2020).

Finally, the IDLM suggests that, although reading and writing development are closely tied, this connection is *asymmetrical*, meaning that reading has more of an influence on writing than vice versa (Shanahan, 2016). The act of writing typically involves reading; for example, students read words they have written to verify that they are spelled correctly (Ehri et al., 1997). This asymmetrical relationship has been demonstrated in longitudinal studies, which indicated unidirectional relations from reading to writing for lexical and discourse-level skills (Ahmed et al., 2014; Kim et al., 2018). Given the asymmetrical nature of reading-writing relations for students with reading or writing difficulties, it is more likely that students with writing difficulties will have co-occurring reading difficulties than vice versa (Kim, 2022).

These theoretical and empirical insights into how early reading-writing difficulties co-occur have several implications for the development of elementary literacy interventions. First, because relations are *hierarchical*, it is critical to intervene on reading or writing difficulties early, to prevent compounding difficulties in both subjects. Second, because relations are *interactive*, a reading problem will likely not remain a reading-only problem, nor will a writing problem remain a writing-only problem. Third, because relations are *dynamic*, interventions that include activities targeting lower-order skills may be beneficial to struggling elementary students

across grade levels, as their discourse-level skills are likely constrained by these skills. Finally, because relations are *asymmetrical*, many students who struggle in writing likely also struggle in reading; as a result, interventions in writing may serve the dual purpose of supporting these students' reading and writing development.

Lack of Effective Writing Intervention Implementation

Despite the potential utility of elementary writing interventions in supporting reading, they are not implemented widely. In U.S. schools, reading is generally more valued than writing, which results in a de-emphasis on instruction in writing (Fitzgerald & Shanahan, 2000; Shanahan, 2016). Potentially because writing is not prioritized, teachers are often not prepared to deliver writing instruction. In a national survey, most elementary teachers reported that their teacher education programs had poorly or only adequately prepared them to teach writing effectively (Cutler & Graham, 2008). A more recent survey also found that elementary special education teachers believed that they were less prepared to teach writing than general education teachers and held more negative attitudes about teaching writing (Graham et al., 2022). Further, students typically spend little time writing, and teachers spend little time teaching writing (Graham, 2019; Spear-Swerling & Zibulsky, 2014; Troia et al., 2015). Given that many students experience writing difficulties (National Center for Educational Statistics, 2012), these findings are concerning. However, if reading is prioritized in education, both in terms of value and instructional time, it is possible that evidence demonstrating the utility of writing interventions to increase reading outcomes will eventually lead to increased implementation. Thus, research is needed to understand how writing interventions may have a positive impact on elementary students who struggle with literacy skills.

Writing Instruction and Students' Reading Outcomes

Including writing as a part of reading instruction has been found to positively impact a broad range of students' reading outcomes. Graham et al. (2018b) conducted a meta-analysis investigating the effect of instruction that balanced reading and writing on the reading of students in Grades Pre-K to 12 and found positive effects on decoding (*ES* = 0.53), vocabulary (*ES* = 0.35), and reading comprehension (*ES* = 0.39). Additionally, instruction that equally balanced reading and writing was associated with stronger effects (*ES* = 0.67) than instruction that focused more on reading (*ES* = 0.33). Although this meta-analysis included only two studies that examined effects of reading-writing instruction on elementary students with literacy difficulties, the effect of reading-writing instruction for this population of students was studied further by Gersten et al. (2020). They found that, for students with reading difficulties in Grades 1 to 3, code-focused interventions that included writing were associated with stronger reading effects. These meta-analyses provided critical evidence for the supplementary role writing plays in reading development; however, research focusing on the effects of writing instruction alone would allow researchers to isolate whether writing has a unique effect on reading for these students.

Other meta-analyses have indicated that writing instruction alone can have a positive impact on reading outcomes, but the extent to which these effects hold for elementary students with literacy difficulties is unclear. Graham and Hebert (2011) found that teaching students how to generate text improved their word reading (*ES* = 0.62), reading fluency (*ES* = 0.66), and reading comprehension (*ES* = 0.22). However, only five of the 95 studies in the meta-analysis included elementary students with literacy difficulties. In another meta-analysis, Graham and Santangelo (2014) found that spelling instruction in partiular improved preschool to twelfth-

grade students' phonological awareness (*ES* = 0.51), word reading (*ES* = 0.40) and reading comprehension (*ES* = 0.66). This synthesis included 11 studies with elementary students with literacy difficulties out of 53 total, but separate effects were not reported. Together, these findings suggest that writing instruction can positively influence a range of reading outcomes, but more research is needed to understand whether, and under what conditions, writing instruction can support elementary students with literacy difficulties.

Potential Factors Influencing the Success of Writing Interventions

In a meta-analysis of the effects of writing instruction on the reading outcomes of students with literacy difficulties in Grades Pre-K to 5 (E. Shanahan, 2023), I identified 21 eligible studies (Berninger et al., 2002, 2006; Craig, 2006; Croes, 1990; Davis, 2000; Edwards, 2001; Ehri & Wilce, 1987; Fuchs et al., 2006; Graham et al., 2002; Hebert et al., 2018; Mason et al., 2013; O'Connor & Jenkins, 1995; Ouellette & Sénéchal, 2008; Roberts & Meiring, 2006; Sénéchal et al., 2012; Simmons et al., 2007; Thompson, 2015; Torgesen et al., 2018; Weiss, 1992; Wolbers et al., 2018; Woodruff, 2014). These studies included 23 treatment conditions and used randomized control trial (RCT; $n = 17$) and quasi-experimental (QE; $n = 4$) designs. There were 88 effect sizes, 33 of which were comparisons between writing and reading treatments, and 53 of which were comparisons between writing treatments and control conditions. I found that writing instruction did have a positive effect on the reading outcomes of elementary students with literacy difficulties ($g = 0.27$, 95% CI [0.14, 0.40], $p < 0.005$; model fitted using robust variance estimation). I also found substantial heterogeneity of effects ($I^2 = 53.49\%$; Higgins et al., 2019); however, pre-selected moderators (type of comparison condition, type of reading outcome, type of outcome measure, instructional dosage, and student group size) were not significantly associated with effects. The non-effect of comparison conditions on effects may

suggest that writing instruction is effective for reading, regardless of whether it is compared to reading or control conditions. These unpublished findings should be interpreted with caution, however, because I found evidence of publication bias based on a visual analysis of a funnel plot of effects versus standard errors.

Although this moderator analysis suggests that writing instruction may have a unique and positive influence on a range of reading outcomes for elementary students with literacy difficulties, they do not explain the conditions under which writing instruction is effective. Thus, I present evidence from broader, relevant syntheses alongside subgroup effects from my meta-analysis to explore potential factors that could influence elementary writing intervention effects on reading below.

Intervention Intensity

Multiple factors may influence the magnitude of writing intervention effects for elementary students with literacy difficulties. First, intensive interventions, or interventions that are (a) delivered at a high dosage in a small group and (b) individualized to students' needs may be more effective. If deficits in shared sources of knowledge cause co-occurring difficulties (e.g., Kim, 2022), these students likely experience multiple interacting difficulties, and thus may require interventions at a higher dosage in a smaller group to address all skills requiring support. Reading interventions that include writing activities and that are delivered at a higher intensity (smaller group sizes, higher dosage) in comparison to a lower intensity have been found to have stronger effects on a wide range of elementary reading outcomes (e.g., Donegan et al., 2020; Denton et al., 2006; Togensen et al., 2001).

Despite these promising findings, a clear impact of dosage on elementary literacy intervention outcomes has not been established. Previous literacy intervention meta-analyses

have found that total intervention hours does not significantly moderate reading effects (Donegan et al., 2021; Gersten et al., 2020; Wanzek et al., 2016, 2018). Descriptively, however, interventions that are 63 hours or longer have been found to have slightly stronger effects (g = 0.45, 95% CI [0.34, 0.56]) than those with fewer hours (g = 0.33, 95% CI [0.17, 0.50]) for students in kindergarten to third grade (Wanzek et al., 2018). Additionally, Donegan et al. (2021) found that for students in Grades 4 and 5, 16-to-30-hour dosages were associated with stronger effects (g = 0.35, 95% CI [0.07, 0.62]) than shorter interventions (g = 0.24 [-0.07, 0.54]) for foundational reading outcomes. However, in my meta-analysis of the effects of writing instruction on reading outcomes for elementary students with literacy difficulties, only dosages of 19 hours or less had a significant, positive effect on reading (g = 0.29, 95% CI [0.22, 0.35]). Thus, it is not clear if more hours of writing intervention can explain variations in reading outcomes.

As with dosage, the effect of intervention group size on elementary literacy intervention outcomes is unclear. Group size has been found to be a significant moderator of intervention effects for first grade students, with stronger effects from one-to-one interventions (Gersten et al., 2020). However, for kindergarten to third grade students' reading outcomes, and fourth and fifth grade students' foundational reading outcomes, group size was not a significant moderator (Donegan et al., 2021; Wanzek et al., 2018). In my meta-analysis, I found that all student group sizes (1 to 2, 3 to 5, and 6 or more) were positively associated with reading effects, but only the coefficient for student groups of 6 or more was significant. These findings indicate that group size may influence the effect of elementary literacy interventions, but more research for writing interventions is needed.

Given that the evidence of the impact of high dosage and small group literacy instruction on reading is mixed, it is possible that an additional instructional intensity-related factor, individualization, may explain variation in effects. There can be multiple sources of shared reading-writing difficulties (e.g., Kim, 2020); as a result, students may benefit from writing intervention that is not only delivered at a high dosage in a small group, but which is also individualized to their needs. McMaster et al. (2020) found that teacher professional development supporting implementation of individualized early writing instruction had promising positive effects on the writing outcomes of students with writing difficulties. In this study, teachers individualized instruction using the DBI framework (Deno & Mirikin, 1977; Fuchs et al., 2014). DBI involves setting and monitoring students' progress towards a long-term goal and making systematic instructional decisions that may include intensifying instruction (e.g., increasing dosage, behavioral support; Fuchs et al., 2018). DBI has had positive effects on academic outcomes for students with learning difficulties (Jung et al., 2018). Conversely, in their meta-analysis of elementary literacy interventions, Donegan et al. (2021) did not find that more broadly "individualized" intervention (i.e., intervention targets/materials planned/adjusted based on individual student progress) significantly moderated effects. The authors noted that no included studies used DBI, and I also did not find any elementary writing intervention studies with reading outcomes that used DBI in my meta-analysis. Thus, broadening the DBI literature base through additional experimentation is necessary (Fuchs et al., 2021).

Student Grade Level

Theoretically, grade level would influence the effect of intensive writing intervention on reading, because reading and writing are more closely connected for younger students who are presumably working on foundational skills (e.g., Shanahan, 2016). However, upper elementary

students who need support with foundational skills may still benefit from this close connection. Therefore, examining the effect of grade level, as a proxy for global developmental stage, on the effectiveness of writing on reading among students who require foundational writing support is critical. Grade level has not been found to be a significant moderator of reading outcomes in meta-analyses of elementary literacy intervention literature (Gersten et al., 2020; Wanzek et al., 2016, 2018). Conversely, in my meta-analysis, I found that writing instruction only had a significant positive effect on reading for students in grades Pre-K to 1 (g = 0.33, 95% CI [0.22, 0.44]). However, grade level was connected to the type of intervention, with lower elementary students receiving more foundational writing interventions. Thus, a single experiment investigating the effects of data-based writing instruction for students across elementary grades, with a constrained range of intervention activities being delivered, may be a more appropriate method of estimating effects by grade level.

Student Reading Difficulty

Finally, students' level of reading difficulty may influence their reading outcomes in the context of writing intervention. Although level of reading risk among elementary students has not been found to moderate literacy intervention effects (Gersten et al., 2020), the same may not be the case for writing interventions in which students are identified based on writing difficulties. Not all elementary students with writing difficulties experience reading difficulties (Costa et al., 2016). As a result, students without reading difficulties may experience fewer added reading benefits from writing interventions. In my meta-analysis, I found that, while writing instruction had positive effects on reading outcomes for elementary students who were identified as having either writing difficulties or reading difficulties, only effects for students identified based on reading difficulties were significant (g = 0.25, 95% CI [0.17, 0.32], $p < 0.05$). Experiments

evaluating the effects of writing intervention on reading outcomes should therefore evaluate and account for students' level of reading difficulty in their analyses.

Type of Reading Outcome

It is also important to note that for elementary students who are experiencing reading and/or writing difficulties, foundational reading skills may be appropriate learning targets if they are in earlier stages of word reading development (Ehri et al., 1997). For example, in my meta-analysis, writing instruction was associated with significant positive effects on word reading (g = 0.29, 95% CI [0.22, 0.35], $p < 0.001$), but not reading comprehension (g = 0.04, 95% CI [-0.09, 0.16]). It is possible that these non-effects were due to the fact that the majority of studies used lexical-level difficulty inclusion criteria (n = 21, 61.9%), and students needed foundational support before making gains in higher-level skills. Interestingly, effects on letter-sound identification were not significant (g = 0.09, 95% CI [-0.07, 0.24]). This finding is surprising, given that letter-sound knowledge is a necessary step for word reading development. However, there were only seven letter sound effects included in this meta-analysis; thus, more research is needed.

Writing Intervention and Reading Outcomes: A Call for More Research

The need for more research investigating the impact of writing interventions on elementary students' reading outcomes has been well-documented in the literature. Graham (2020) argued that students with disabilities and experiencing academic difficulties must be made a priority in reading-writing development research. Additionally, he called for the identification of precise catalysts that contribute to the individual and mutual development of specific reading and writing skills at different points in students' education. Shanahan (2006) similarly stated that research that can lead to the design of efficient and effective combined

reading and writing instruction is needed. Investigating the magnitude and nature of elementary writing intervention effects on reading outcomes will bring the research community closer to understanding how to best support younger students with reading and/or writing difficulties.

The Current Study

The purpose of this dissertation was to respond to the call for research investigating the effect of elementary writing intervention on reading outcomes. I examined this effect using data collected as part of a larger randomized control trial (RCT) of early, data-based writing instruction for students with significant writing difficulties. Determining whether, and how, elementary writing intervention can positively influence reading is critical, given that many students with writing difficulties experience reading difficulties, and writing interventions are sparsely implemented. Thus, the current study is guided by the following research questions:

1. To what extent do elementary students with significant writing difficulties also experience foundational reading (letter sound knowledge, decoding) difficulties?
2. What is the effect of data-based writing instruction on the foundational reading outcomes of students with significant writing difficulties?
3. Are the effects of data-based writing instruction predicted by students' pretest reading scores and grade level?

Chapter 2: Literature Review

Findings from previous meta-analyses outlined in the Introduction provide insight to potential effects of writing instruction on reading outcomes for students with literacy difficulties, and factors influencing these effects. Yet, an additional issue should be considered before concluding that writing interventions can positively influence reading for young students with literacy difficulties in the same manner that reading can. Reading and writing are not perfectly reciprocal skills; the asymmetrical relations between reading and writing suggest that interventions in one domain will more successfully increase outcomes in the same domain (Kim, 2020; Shanahan, 2016). A necessary next step that would inform the implications of a writing intervention that successfully promotes reading skills is to compare the impacts of reading and writing interventions on reading outcomes. Thus, this literature review is guided by the following research questions:

1. What are the effects of (a) writing interventions and (b) reading plus writing (RPW) interventions on the reading outcomes of elementary students experiencing reading or writing difficulties?
2. Do writing intervention effects vary by reading outcome?
3. Do writing and RPW intervention effects vary by writing activities and student grade level?

Method

Eligibility Criteria

To determine the effect of elementary writing intervention on student reading outcomes, I included studies that met the following criteria: (a) students were in preschool to Grade 5; (b) only students identified as having difficulties in reading and/or writing were included; (c) a

small-group (fewer than six students, or reported by authors as “small group”) intervention including writing activities was conducted; (d) studies employed a randomized-control trial (RCT) or multiple baseline single-case experimental design (SCED); and (e) the study was written in English and in a peer-reviewed journal. The purpose of applying the stringent criteria of randomized-control trial and peer-reviewed journal was to increase the likelihood of identifying studies with rigorous research design.

Search Procedures and Selection of Studies

I applied two strategies to identify studies for this review. First, electronic searches (ending February 2022) were conducted in the databases Academic Search Premier, PsycINFO, and Education Source. After the removal of duplicates, this search yielded 13,376 articles. I screened abstracts by excluding articles that did not mention writing skills as either an intervention activity or outcome variable. For the purposes of this paper, interventions were operationally defined as instruction intended to remediate reading and/or writing skill deficits. After screening abstracts and full text, I identified 25 articles eligible for inclusion in this review. Second, I identified 22 previously-published literature reviews investigating the effect of writing or RPW interventions on students’ reading outcomes, from the database search. I screened the full-text of articles included in those reviews, which yielded seven additional eligible articles. Thus, the total number of articles included in this review was 30.

Coding of Studies

In each study, I first coded whether the intervention was presented by the authors as a writing intervention or RPW intervention. The act of writing inevitably involves reading because writers typically reread words they write or consult texts to generate ideas for writing (Ehri et al.,

1997; Shanahan, 2016). However, authors' characterization of programs as writing interventions likely indicates that the primary focus of intervention activities was writing-only.

I then reviewed intervention procedures to code for the following targeted skills in reading: letter name identification, letter sound identification, phonemic awareness, decoding, sight word reading, reading fluency, vocabulary, and reading comprehension. I also coded for the following targeted skills in writing: handwriting, letter sound writing, spelling, syntax, sentence generation, passage generation, and self-regulation. When available, I recorded the amount of intervention session time spent on each activity. I categorized interventions as focusing on transcription if activities included handwriting, letter sound writing, and/or spelling activities. I categorized interventions as text-generation if activities included syntax, sentence generation, or passage generation activities. Studies that included self-regulation activities (e.g., planning, editing) were coded as self-regulation. Interventions that included activities from more than one category were multiply coded (e.g., text generation plus self-regulation). I coded intervention reading outcomes as letter name knowledge, letter sound knowledge, phonemic awareness, word reading, reading fluency, vocabulary, reading comprehension, and reading achievement.

I also coded for student grade level and grade level band, as well as how students were determined to have difficulties in reading and/or writing. Finally, I coded for experimental design (RCT or SCED). To determine intervention intensity, I coded the following intervention features: group size, intervention duration, session time, session frequency, total number of sessions, and total intervention time. When possible, I calculated total intervention time based on other dosage-related information. I also recorded whether the interventionists used the DBI framework to intensify instruction.

I evaluated study quality using methodological standards from the Council for Exceptional Children (CEC, 2014). CEC standards include quality indicators (QIs) that are specific to group experimental design or SCED, or that target both design types. Specific CEC QIs of interest for this review include whether the following was reported: (1) intervention setting (e.g., type, location); (2) participant demographic characteristics (in addition to student disability or at risk status, which was described in all studies); (3) intervention agent role; (4) intervention agent training; (5) description of intervention materials (in addition to intervention components, which were described in all studies); (6) intervention protocol adherence at proportions $\geq$ 0.80 or 80%; (7) low student attrition (overall attrition < 30%, differential attrition $\leq$ 10%; group design only); (8) outcome measure reliability evidence with coefficients $\geq$ 0.80; and (9) effect sizes or sufficient data to calculate effect sizes (group design only). Consistent QI areas of strength (i.e., $\geq$ 80% of studies demonstrating) and weakness (i.e., < 80% of studies demonstrating) are reported in this review.

Data Analysis

In all but two RCTs in this review, effect sizes or sufficient information to calculate effect sizes was reported. When possible, I calculated posttest effect sizes for RCTs using Cohen's *d* (Cohen, 1988) and an online effect size calculator (www.socscistatistics.com/effectsize). Cohen's *d* values were interpreted using guidance by Sawilowsky (2009), which expanded Cohen's initial guidance (1988) to include very small and large effects. I defined $0.01 \leq d < 0.2$ = very small; $0.2 \leq d < 0.5$ = small; $0.5 \leq d < 0.8$ = medium; $0.8 \leq d < 1.2$ = large; $1.2 < d < 2.0$ = very large, and $d \leq 2.0$ = huge. For SCED studies, I conducted visual analyses of graphs to determine whether each case (student) demonstrated a level and/or trend change between their baseline and intervention phase.

To address Research Question 1, what are the effects of (a) writing interventions and (b) RPW interventions on the reading outcomes of elementary students experiencing reading or writing difficulties, I reported average and ranges of RCT effect sizes by intervention type.

To address Research Question 2, do effects of writing interventions vary by reading outcome, I synthesized effects from writing-only interventions. I excluded RPW interventions from this portion of the analysis because their focus on reading would likely inflate reading outcomes, making comparisons between outcomes difficult.

To address Research Question 3, do effects of writing and RPW interventions vary by writing activity and student grade level, I synthesized effects from all studies. Effect synthesis for all three topics included average and ranges of RCT effect sizes, as well as the results of SCED visual analysis. For effect synthesis by reading outcome and writing activity, I also included author reported significant or nonsignificant effects in RCTs when data was not available to calculate effect sizes.

Results

After applying the search and screening procedures, I identified 30 studies as eligible for review. In the following sections, I summarize studies' participant and intervention characteristics, as well as intervention effects.

Characteristics of Included Studies

For an overview of study, participant, and intervention characteristics, see Table 1. Study designs were RCT (n = 25) and SCED, multiple-baseline across participants (n = 5).

Participants. Student participants were most frequently in lower elementary grades (Grades K-2; n = 18), followed by upper elementary (Grades 3-5; n = 8) and across elementary (n = 4) grades. Eligibility to participate in interventions was most frequently determined by cut

scores on a standardized assessment (*n* = 12). Studies most often included students on the basis of reading difficulties only (*n* = 21), specifically word reading difficulties (*n* = 14). Only four studies used both reading and writing difficulties as eligibility criteria. Among studies that based eligibility on writing only (*n* = 5), only two reported that participating students, on average, experienced co-occurring reading difficulties (Graham et al., 2002; Lane et al., 2009). Among studies that based eligibility on reading only, only five reported that participating students, on average, experienced co-occurring writing difficulties (e.g., Blachman et al., 2004).

Eleven studies had student exclusion criteria, which was most commonly student emergent bilingual/multilingual status (including eligibility for English learner services, non-native English speaker status, and having a language besides English spoken at home; *n* = 5), and disability status (most frequently intellectual disability, *n* = 5). Nineteen studies either did not report or did not have exclusion criteria. Given that teacher or student participants typically were sampled from general population schools, it is possible that the de facto exclusion of students with significant disabilities, served in self-contained settings, occurred.

Intervention Characteristics. In most eligible studies, authors characterized their interventions as RPW (*n* = 22). The remaining eight interventions were characterized as writing interventions. However, of these writing interventions, five included at least one reading activity (e.g., Senechal et al., 2012). The writing focus of most interventions was transcription-only (*n* = 19), followed by transcription plus text generation (*n* = 4), and text generation-only (*n* = 3). Five studies included self-regulation as a writing focus; self-regulation activities only occurred alongside text generation activities. The most commonly targeted reading skill was phonemic awareness (*n* = 17), and the most commonly targeted writing skill was spelling (*n* = 22). Only one intervention was not multi-component, a computerized spelling intervention study (Fuchs et

al., 2006). Only seven studies reported enough information to calculate the percentage of lesson time spent on writing activities, which averaged 47% (22% in RPW, 81% in writing only). See Table 2 for intervention activities by study.

Intervention Intensity. Most interventions were conducted with a one-to-one student-interventionist ratio (n = 18), with additional ratios ranging from two- to six-to-one. Two studies reported only that the interventions were conducted in small groups. Average intervention session time was 28 min (range = 10 to 60 min); RPW intervention sessions were longer than writing interventions on average (30 min versus 24 min, respectively). Two studies did not report intervention session time. Twenty-six studies reported sufficient information to calculate the total number of intervention hours, which on average was 27.3. RPW interventions had considerably more total intervention hours than writing interventions (M = 34.1 versus M = 8.8 hours, respectively).

The total number of intervention sessions conducted ranged widely (seven to 140), with an average of 49 sessions. Five studies did not report sufficient information to calculate the number of intervention sessions. RPW interventions included more sessions than writing interventions, on average (60 and 30, respectively). Six studies included over 100 sessions, and thus may be considered intensive interventions (e.g., Wanzek et al., 2018; Wanzek & Vaughn, 2008). No writing interventions were intensive. Additionally, no included interventions incorporated the DBI framework to intensify instruction.

Study Quality. Out of nine QIs of interest to this study, studies demonstrated an average of 7.7 (range = 4 to 9). Eighty percent or more studies described the intervention setting, two or more participant demographic characteristics, intervention agent roles, intervention materials, outcome measure reliability with coefficients $\geq$ 0.80, and sufficient data to calculate effect sizes

for all reported measures (group design only). Less than 80% of studies described or reported how intervention agents were trained, intervention adherence, and low student attrition (group design only). Two group design studies did not report sufficient data to calculate effect sizes or actual effect sizes on any reading outcome measures (Berninger et al., 1995; Englert et al., 1991).

Effects of Included Studies

On average, writing and RPW interventions had a positive, medium effect on the reading outcomes of elementary students with reading or writing difficulties (d = 0.54, k = 98); however, effects varied widely (range = -0.56 to 2.26). RPW interventions had a stronger effect on reading outcomes (k = 86; d = 0.57, range = -0.23 to 2.26) than did writing interventions (k = 12; d = 0.37, range = -0.56 to 1.86).

Writing Intervention Effects by Reading Outcome. The effect of writing-only interventions on reading varied by reading outcome. Three studies had sub-lexical reading skills as outcomes. One intervention, which targeted handwriting, had a very large positive effect on first grade students' letter name knowledge (d = 1.86; Berninger et al., 1997). Another intervention including spelling and decoding activities had a medium positive effect on kindergarteners' letter sound knowledge (d = 0.60) and a small effect on phonemic awareness (d = 0.36; Senechal et al., 2012).

Five writing interventions had word reading as an outcome. These studies included kindergarten through third grade students. All interventions had spelling activities and three included letter sound, phonemic awareness, and/or decoding activities. There was a small positive effect on word reading (k = 6; d = 0.39, range = 0.12 to 0.84). However, Berninger et al. (1995) reported that their handwriting, spelling, passage generation, and self-regulation intervention had nonsignificant effects on word reading.

Three studies examined the effect of writing intervention on reading comprehension, to varying effects. One intervention, which included passage generation, self-regulation, and reading comprehension activities for fourth and fifth grade struggling writers, had a negative effect on reading comprehension (d = -0.5; Hebert et al., 2018). Hebert et al. suggested that this non-effect (reported as such in the article; actual effect size value was calculated by me for the purposes of this paper) could be due to the brevity of the intervention (12 sessions) and the fact that reading comprehension measures included items of untaught text structures for writing. Fuchs et al. (2006) found a positive effect of their first-grade spelling intervention, delivered across 50 sessions, on a distal reading comprehension measure (d = 0.33). Additionally, Englert et al. (1991) reported that their passage generation and self-regulation intervention, which was conducted over the course of six months, had significant effects on reading comprehension.

Writing and Reading Plus Writing Intervention Effects by Writing Focus and Activity. For both writing and RPW interventions, effects by writing focus were as follows: transcription-only (k = 51; d = 0.45), text generation-only (k = 25; d = 0.86), transcription plus text generation (k = 18; 0.51), text generation plus self-regulation (k = 2; d = 0.57 for reading comprehension only); and transcription, text generation, plus self-regulation (k = 2; d = -0.5 for reading comprehension only).

Studies most frequently included spelling (n = 22) and passage generation (n = 10) activities. Interventions that included spelling activities were associated with medium effects on letter sound knowledge (k = 1; d = 0.60), word reading (k = 37; d = 0.52, range = 0.09 to 1.28), and reading achievement (k = 2; d = 0.61, range = 0.31 to 0.91). Additionally, in four SCED RPW interventions including spelling activities, 11 out of 12 students experienced a positive level and trend change in word reading scores (Alber-Morgan et al., 2016; Joseph, 1999; Joseph,

2002; Keesey et al., 2015). Vernon-Feagans et al. (2012), a RPW intervention study, included spelling activities, but reported non-significant effects on phonemic awareness.

Interventions including passage generation activities were associated with large effects on phonemic awareness (k = 7; d = 1.05, range = 0.40 to 2.26), and medium effects on vocabulary (k = 1; 0.56), word reading (k = 9; d = 0.53, range = 0.18 to 1.81), and reading fluency (k = 8; d = 0.57, range = 0.16 to 1.15). Overall, interventions including passage generation activities had a positive effect on reading comprehension, but effects varied widely (k = 9; d = 0.56, range = -0.56 to 1.51). RPW interventions showed a consistent pattern of stronger effects on reading comprehension than writing-only interventions (k = 4; d = 0.85, range = -0.02 to 1.51). Additionally, one SCED RPW intervention produced positive level changes in reading comprehension scores for four out of five participating students. It should be noted that no eligible studies included interventions with activities targeting written syntax. Additionally, only one study each included letter sound writing or sentence generation activities.

Writing and RPW Intervention Effects by Grade Level. Writing and RPW intervention effects were similar across grade levels. Many studies included students from multiple grade levels (n = 12) and did not report effects by specific grade level; I therefore report effects by grade level band. Interventions had a medium effect on lower- (k = 72; d=0.54, range = -0.23 to 1.67) and upper-elementary students (k = 21; d = 0.54, range = -0.56 to 1.81), as well as students spanning both lower- and upper-elementary grades (k = 5; d = 0.68, range = 0.51 to 0.84).

Effects on specific reading outcomes varied by grade level band and outcome. Among the four lower-elementary studies examining reading comprehension outcomes, effects were medium (k = 7, d = 0.67). Among the eight studies with upper-elementary students, effects were

small (k = 7, d = 0.17). It should be noted, however, that none of these upper-elementary studies identified students as having difficulty in reading comprehension alone (most [n = 4 studies] were identified by word reading difficulties). In contrast, word reading effects were consistent across lower and upper-elementary grade bands (k = 37, d = 0.54 and k = 10, d = 0.53, respectively).

Discussion

The purpose of this literature review was to investigate the effect of writing and reading/writing intervention on the reading outcomes of elementary students with reading or writing difficulties. Both writing and RPW interventions had positive effects on reading outcomes (d = 0.54), but effects were stronger for RPW interventions (d = 0.57) than writing interventions (d = 0.37). Writing intervention effects were small to medium across reading outcomes, with the exception of mixed effects for reading comprehension outcomes. Writing and RPW intervention effects varied by writing activity included in the interventions. Effects were, however, consistent across lower and upper-elementary grade levels for word reading outcomes. In the following sections, I review the implications of these findings, implications for practice, and directions for future research.

Impact of Writing and RPW Intervention on Reading Outcomes

The finding that writing interventions had a positive impact on the reading outcomes of elementary students experiencing literacy difficulty is consistent with the IDLM (Kim, 2020). Given that reading and writing are fundamentally connected skills that draw on shared knowledge, it follows that instruction in one skill would benefit the other. Further, this result supports the argument that learning can be strengthened by reexamining information (for

example, the sounds associated with letters in a printed word) from a different perspective (e.g., spelling the word when dictated to; McGinley & Tierney, 1989).

Although writing interventions were effective in increasing reading outcomes, RPW interventions had stronger effects. This result is consistent with theoretical and empirical evidence that the relationship between reading and writing is asymmetrical, with reading taking a more dominant role in the development of both skills (e.g., Ahmed et al., 2014; Fitzgerald & Shanahan, 2000). Reading and writing place different demands on linguistic knowledge and cognitive processes (Langer, 1986); thus, instruction in one domain tends to be more beneficial for improving skills in that same domain (Shanahan, 2016). Students with reading difficulties must receive reading intervention; yet the findings of this review suggest that they may also benefit from the inclusion of writing activities in their reading interventions.

In addition to theoretical explanation, factors related to study design may also explain differences between RPW and writing intervention effects. RPW interventions were delivered at a higher dosage (M = 34 hours, versus M = 9 hours). Additionally, there were far more RPW studies eligible for inclusion (n = 22 versus n = 8). More writing intervention studies delivered at a higher dosage are needed for the asymmetrical reading-writing relation hypothesis to be supported in the context of elementary students with literacy difficulties.

Intervention Effects by Reading Outcome, Writing Activity, and Grade Level

Writing intervention effects were strongest for sublexical and lexical-level reading skills, which is consistent with empirical evidence suggesting that reading-writing relations are strongest at these levels (e.g., Ahmed et al., 2014). Writing interventions may not have had a consistent positive effect on reading comprehension because reading-writing relations are weaker at the discourse level. However, one additional explanation may be that students included in

these studies required more foundational support before gains in reading comprehension could be made.

Specific writing activities were associated with positive effects on a range of reading skills, suggesting that interactive reading-writing effects occurred. Spelling and passage writing activities were included most frequently and demonstrated positive effects across the hierarchy of reading skills. The finding that spelling activities were associated with positive word reading effects is perhaps not surprising, as the connection between these two lexical-level skills is well-established (e.g., Graham & Santangelo, 2014), as is the effect of word reading interventions on spelling outcomes (e.g., Wanzek et al., 2006). However, spelling activities also had a positive impact on a variety of sublexical and discourse-level reading skills. Similarly, interventions including passage generation not only had positive effects on reading fluency (another discourse-level skill), but also on sublexical and lexical-level skills. These level-spanning effects suggest that targeting spelling and passage generation in interventions can have a direct or indirect positive impact on students' holistic reading development.

The finding that writing and RPW interventions were similarly effective for lower- and upper-elementary students' word reading is encouraging and consistent with research indicating that students across elementary grade levels can benefit from literacy intervention (e.g., Al Otaiba et al., 2022). Among students who are meeting grade-level expectations for reading and writing development, relations between reading and writing are hypothesized to be strongest in early elementary grades when students are developing highly-interrelated sublexical and lexical-level skills (Shanahan, 1984). However, upper-elementary students included in these studies benefitted from these interventions because they were still developing sub-lexical and lexical-level reading and writing skills.

Implications for Practice

These findings do not suggest that one consistent RPW intervention package will be effective for all students with reading and/or writing difficulties. Instead, teachers may determine with which specific skills students experience difficulty, and design targeted interventions accordingly. For example, if students demonstrate difficulty with both naming letters and handwriting, an intervention that involves students saying the names of letters as they practice writing them may lead to increased outcomes in both skills. Considering ways to combine activities to create efficient reading and writing instruction could be critical to students' literacy success (Shanahan, 2006).

Directions for Future Research

Future researchers may extend these findings by providing more detail on intervention activities. Namely, specifying the proportion of time in intervention sessions spent on each component would allow for conclusions about the effect of time spent writing on reading outcomes. A second gap in the current research is that effects of certain writing activities were not, or were infrequently, examined. Only one study included a letter-sound writing activity (Vaughn et al., 2006). Letter-sound knowledge is critical to the development of decoding (e.g., Ehri, 1997). Writing letter sounds may contribute meaningfully to the development of letter-sound knowledge, as orthographic learning is strengthened and reinforced when taught in the context of both reading and writing (Graham et al., 2018; Shanahan, 1998). Letter writing activities may be particularly useful for elementary students with significant difficulty identifying letter sounds and decoding words with simple consonant-vowel-consonant patterns.

Additionally, no studies included activities that would support written syntax development. Limited syntactic knowledge can constrain students' text generation (Beers &

Nagy, 2011). Additionally, elementary students with reading comprehension difficulties experience difficulty with syntactic aspects of writing, including word usage and syntactic complexity (e.g., Cragg & Nation, 2006; Smith-Lock, 1991). Research is needed to clarify whether intervening on written syntax can support reading outcomes for students with difficulties.

Future researchers should also consider using more inclusive intervention participant criteria. Some studies excluded students on the basis of non-native English language status. Non-native English-speaking status is a broad category that could have included students with a wide range of English proficiency. Among the pool of students considered for inclusion in these studies, there may have been students who had never required English learner services, and therefore any difficulties in reading or writing could not be attributable to language development. Even among students who do receive English learner services, some students may have or be at risk of learning difficulties and disabilities unrelated to their language proficiency. Approximately 11.8% of students with disabilities in the United States receive English learner services (Office of Special Education Programs, 2022). It is therefore likely that emergent multilingual students who could have benefitted from writing interventions were excluded from these studies. In addition to non-native English-speaking students, students with below-typical IQs were also excluded. Students with below-typical IQs, including students with mild to severe intellectual disabilities, learn literacy skills when provided appropriate instruction (Allor et al., 2014; Spooner et al., 2012). Therefore, the students with below-typical IQs who were excluded from studies in this literature review could have experienced increased reading outcomes if given the opportunity to participate. Including all students who would benefit from writing or RPW

intervention would not only increase the generalizability of the findings; it would also have a positive impact on the academic outcomes of students from these marginalized populations.

Finally, future research may investigate the impact of intensive writing intervention on reading outcomes. No writing-only interventions were intensive in terms of dosage. Furthermore, writing intervention dosage was much lower than RPW interventions (M = 8.8 versus 34.1 total hours, respectively). Also, no interventions were individualized using DBI. This finding is concerning, given that addressing co-occurring reading and writing difficulties likely require multicomponent and sustained instruction (Graham et al., 2012; Graham & Perin, 2007; Vaughn et al., 2015; Wanzek et al., 2013, 2016, 2018). The majority of studies in this review included students who had difficulties in multiple reading or writing skills, which could have resulted from downstream effects of lower-level skills (Kim, 2022). These students therefore may have been experiencing significant learning difficulties and could have benefitted from interventions delivered over an extended period of time. Additionally, because reading and writing difficulties can co-occur for a range of reasons (Kim, 2022), interventions that were individualized to specific student needs using DBI may have been beneficial. More research is needed, however, to determine whether evidence supports this hypothesis.

Limitations

The findings of this literature review should be interpreted in the context of three limitations. First, I used stringent abstract screening criteria to identify studies that included writing intervention activities. Namely, reading intervention studies that did not mention writing as either an intervention activity or outcome were excluded. As a result, it is possible that reading interventions that did include a writing activity, however brief, were excluded. Thus, the comparison between RPW and writing-only interventions should be interpreted with caution.

This abstract screening criteria would not have excluded any writing intervention studies, however; therefore, I conclude that the effects of writing-only intervention studies can be interpreted with confidence.

Second, I used rudimentary meta-analytic methods to calculate summary effect sizes. Future research may include a meta-analysis that investigates effects using moderators, such as intervention type (writing versus RPW), study quality, intervention dosage, and student grade level.

Third, studies included student participants identified as having reading, writing, or both reading and writing difficulties. While intervention effects were positive across these three groups, effects varied, with students identified as having both reading and writing difficulties experiencing the largest effects ($k = 67$, $d = 0.41$; $k = 9$, $d = 0.75$; $k = 22$, $d = 0.88$, respectively). It is likely that many students identified as having reading difficulties also experienced difficulties in writing, and vice versa (e.g., Kim, 2022; Graham et al., 2020). However, some variation in reading outcomes may be due to the fact that not all students had difficulties with reading, and thereby made minimal improvement in response to intervention. Future research on the effects of writing or RPW interventions on reading outcomes should consider including only students who are confirmed to need support in both subjects.

Conclusion

The findings of this literature review indicate that writing interventions can result in positive reading outcomes for students with reading or writing difficulties. Patterns of effects by reading outcome and student grade level are consistent with theories of connected reading and writing development. Critical next steps in understanding how writing intervention can support reading include examining the effects of multicomponent writing interventions, including all

students who would benefit from such intervention, and investigating the impact of intervention intensity on students' reading outcomes.

Chapter 3: Method

The current study was intended to examine the effects of data-based writing instruction on elementary students' foundational reading outcomes. All data used in this study were drawn from a larger study evaluating the effects of a professional development program, Data-Based Instruction: Tools, Learning, and Collaborative Support (DBI-TLC; Lembke et al., 2018; McMaster et al., 2020) designed to support teachers' use of DBI for early writing. This larger study, The Early Writing Project, was conducted as an RCT across three years with three cohorts of teachers. Each year of the study, teachers were recruited and randomly assigned to treatment (in which they received professional development and ongoing coaching across 20 weeks of DBI implementation) or a business-as-usual control group. Only data from the third year of the RCT, in which the research team added measures of students' reading performance, are included in the current study.

Setting and Participants

The third year of the larger study was conducted in 14 public school districts in two Midwestern states during the 2021-2022 school year. Research approval was secured from the institutional review boards of the principal investigators' institutions. Teacher consent was obtained for all participating teachers, and parental consent for all participating students.

Teachers

To be eligible for participation in the larger study, teachers needed to (a) provide direct support to elementary students at risk or with disabilities who experienced difficulty in writing and (b) have at least two years of teaching experience. Project coordinators at both sites connected with various local districts to invite eligible teachers to participate. For random assignment, teachers were first blocked within a school if the school included more than one

participating teacher, and then assigned randomly to groups. If the school included only one participating teacher, that teacher was grouped with teachers at another school with a similar percentage of students receiving free or reduced-price lunch; teachers were then assigned randomly within those matched groups. Forty-nine teachers (23 treatment, 26 control) were participating in the current study before students were screened. Forty-two teachers (19 treatment, 23 control) completed their participation in the study, and seven teachers withdrew (16.7% overall attrition). Three control teachers dropped before their students were screened. Four treatment teachers and their students dropped during the course of the study. For a consort diagram of teacher and student participants, see Figure 1. For teacher demographics, see Table 3.

Students

Participating teachers nominated elementary students in need of intensive writing intervention from their caseloads. We aimed to include students in Grades 1-3, but also allowed teachers to nominate students in Grades 4 and 5 who needed intensive support in alignment with the early writing interventions provided in the study. Nominated students who had parental consent to participate (via a paper form sent home with the student detailing study aims and participation expectations) were screened using two forms each of two CBM-W tasks: Word Dictation and Picture Word (both described in Measures). Researchers then selected the two to three students who scored lowest on both measures (using the mean score from two forms) in each class for study participation.

One hundred sixty-seven students completed screening (83 treatment, 84 control). After screening, 122 students (62 treatment, 60 control) were eligible for study participation. Of these students, 108 (50 treatment, 59 control) completed pretesting. Fourteen eligible students withdrew (12 treatment, 2 control; 11.4% overall attrition) between screening and pretesting for

the following reasons: their teacher dropped (n = 10 students, n = 3 teachers, all treatment), they moved (n = 2, treatment), or they were re-assigned to a non-study participant teacher (n = 2, control).

One hundred five students (46 treatment, 59 control) completed posttest reading measures. Study attrition, meaning attrition of the eligible students that we intended to receive treatment, was 25.8% for treatment and 1.7% for control conditions. Based on independent ANOVA tests, there were no significant differences in any screening and pretest scores, as well as gender, special education status, English language learner (ELL) status, and race/ethnicity (four demographic variables with near-complete data; race/ethnicity included Bonferroni correction for p-values), between eligible students with and without complete posttest data (all p-values above 0.21). Most students were male (n = 71, 67.6%), white (n = 53, 50.5%), in second grade (n = 33, 31.4%), did not receive ELL services (n = 80, 76.2%), and had disabilities (n = 73, 69.5%). Among students with disabilities, most had a specific learning disability (n = 22, 21% of full sample). Speech-language disorder was the most common secondary disability (n = 14, 13.3%). For posttested student demographics by experimental condition, see Table 4.

Measures

CBM-W

At screening and posttest, students completed two CBM-W tasks: Word Dictation and Picture Word. At pre- and posttest, students completed Story Prompt. Students completed two forms of each task, and mean scores were used as their final score. These CBM-W measures capture sublexical, lexical, and sentence-level writing skills (Kim, 2020). Each CBM task involves multiple scoring procedures ranging in complexity, intended to capture multiple writing

skills. Each tasks' purpose, administration procedures, and reliability and validity evidence are outlined below.

CBM Word Dictation. Word Dictation is designed to measure students' word-level writing skills. Word Dictation is administered individually for 3 minutes. The examiner dictates words to the student, with one repetition, and the student writes each word. Word Dictation scores include a total of words written, words spelled correctly, correct letter sequences, incorrect letter sequences, and correct minus incorrect letter sequences. The correct letter sequences score is the total of two adjacent letters the student correctly places according to the correct spelling of the dictated word, and the incorrect letter sequences score is the total of two adjacent letters the student incorrectly places (Deno & Fuchs, 1987). The correct minus incorrect letter sequences score is the difference between correct and incorrect letter sequences. Alternate-form reliability for Word Dictation scoring procedures in Grades 1-5 have ranged from r = .81 to .96 (Hampton & Lembke, 2016; McMaster et al., 2020). Criterion validity coefficients from student participants' screening Word Dictation scores and the Kauffman Test of Educational Achievement, Third Edition, Written Language subtest (KTEA-3 WE) ranged from r = .52 to .65.

CBM Picture Word. Picture Word measures students' sentence-level skills. Each prompt consists of pictures labeled with one word; students are instructed to write a sentence for each picture for 3 minutes. Picture Word scores include words written, words spelled correctly, correct word sequences, incorrect word sequences, correct minus incorrect word sequences, and total responses. CWS are scored as the total of two adjacent words spelled and used correctly in a sentence, and the IWS score is the total of two adjacent words spelled or used incorrectly (Videen et al., 1982). The CIWS score is the difference between CWS and IWS scores. The TR

score is the number of picture prompts for which a student wrote at least one complete sentence. For grades 1-5, alternate-form reliability for Picture Word scoring procedures (with the exception of TR) has ranged from *r* = .60 to .91 (Allen et al., 2020; McMaster et al., 2009, 2020; Parker et al., 2011). Criterion validity coefficients from student participants' screening Picture Word scores and the KTEA-3 WE ranged from *r* = .35 to .45.

CBM Story Prompt. Story Prompt captures students' passage-level writing skills. Students are given a prompt with simple vocabulary and sentence structure and reflect experiences that students in the U.S. can relate to (e.g., "All the lights went off and…"). Students have 30 seconds to think of a story they would write using the prompt, and 3 minutes to write a story. Story Prompt scores include words written, words spelled correctly, CWS, IWS, and CIWS. Alternate-form reliability has ranged from *r* = .46 to .92 for grades 1-5 (Allen et al., 2020; McMaster et al., 2011, 2017, 2020). Criterion validity coefficients from student participants' pretest Story Prompt scores and the KTEA-3 WE were *r* = .04 (CIWS), .48 (words written), and .49 (words spelled correctly).

CBM-R

At screening and posttest, students completed one form of two reading CBM (CBM-R) tasks. The CBM-R measures included two subtests from the Formative Assessment System for Teachers™ (FAST™) earlyReading measure from FastBridge Learning. The FAST™ earlyReading subtests were designed to provide domain-specific assessments of component skills in reading, as well as enable efficient screening for reading at the kindergarten and first grade level (Christ et al., 2018). The two subtests used in the current study were Letter Sounds (LS) and Decodable Words (DW).

LS and DW are intended to evaluate letter sound knowledge and decoding skills (Christ et al., 2018), two critical components of early reading (Ritchey & Speece, 2006). LS assesses students' accuracy and automaticity in providing the most common sounds for lowercase letters (short vowels, hard consonants) in isolation. DW assesses students' ability to read phonetically regular words, meaning words that have common phoneme-grapheme relationships and can be decoded (e.g., "dog"). These foundational measures were selected based on the knowledge that student participants from previous cohorts struggled with sentence-level writing skills (in the larger RCT, Cohort 1 and 2 students produced 7.7 and 4.0 CWS in the Picture Word and Story Prompt tasks on average at pretest, respectively). As a result, LS and DW may be sensitive to the growth of elementary students in this sample who require support in early writing skills.

Both LS and DW are timed assessments administered for one minute. Students are directed to say the sound of each letter, or read each word, on a printed page. LS includes 100 letters, and DW includes 50 words. For additional information related to LS and DW administration, see Appendix A. LS and DW are both scored as correct responses per minute, meaning the total correct divided by the total read. The LS score is correct letter sounded per minute (CLSPM), and the DW is words read correctly (WRC). For students who attempted all letters/words in less than one minute, the formula *[# correct/# seconds]*60* is applied to calculate an adjusted score.

Christ et al. (2018) examined the reliability and criterion-related validity evidence for LS and DW. Participants included kindergarten and first grade students from an urban school district in the Midwest. Test-retests coefficients were .92 for kindergarten LS (n = 75), .98 for kindergarten DW (n = 29), and .97 for first grade DW (n = 73). Alternate-form reliability coefficients ranged from .85 to .94 for kindergarten LS (n = 34 to 36; median=.89), .96 to .98 for

kindergarten DW (n = 29; median = .97), and .97 to .98 for first grade DW (n = 36 to 37; median = .98). In a separate study, criterion validity coefficients with the Group Reading Assessment Classification Evaluation (GRADE), a norm-referenced reading achievement test, ranged from r = 0.44 to 0.57 for kindergarten LS, 0.41 to 0.46 for kindergarten DW, and 0.58 to 0.72 for first grade DW (Monaghen, 2014). Although alternate-form reliability and criterion validity coefficients for LS and DW are not available for students in grades two to five, we deemed the measures to be relevant for these students as these students were identified as experiencing significant writing difficulties. Given that reading and writing difficulties may be connected, most of these students may also be experiencing reading difficulties, and many could be working towards mastery of kindergarten- or first grade-level reading skills.

Student Demographic Survey

Student demographic information for all student participants was collected in several ways: a Qualtrics survey completed by participating teachers, a Qualtrics survey teachers used to nominate students for Early Writing Project participation, district demographic data provided by a school or district representative, or via conversations between teachers and graduate research assistants. Information was obtained primarily from the Qualtrics survey and student nomination forms. In addition to 11 questions related to student and teacher identity (e.g., experimental condition, student ID, district), the Qualtrics survey included 8 items related to students' demographic background. These items were: student sex, ethnicity, home language, Free or Reduced Lunch Status, special education eligibility, primary and secondary disability, and federal special education setting. The student nomination form included two demographic items, which were student grade level and ELL status.

Procedures

Data Collection

At screening, students received two forms of Word Dictation and Picture Word, as well as one form of LS and DW. At pretest, students received two forms of Story Prompt. At posttest, students received all measures given at screening and pretest. Graduate research assistants (GRAs; all PhD students in school psychology or special education) and data collectors hired by the University of Minnesota (henceforth referred to as a group as "data collectors") were trained to collect student screening, pre-, and posttest CBM-R and CBM-W data. GRAs also collected ongoing writing instruction fidelity data from teachers. Detailed procedures used to data collectors to administer and score CBMs are outlined briefly below and reported in detail Appendix B. For CBM-R and CBM-W administration fidelity and scoring reliability percentages for each measure and scoring procedure, at training, pre- and posttest, see Tables 3 and 4.

CBM Administration Fidelity and Scoring Reliability. Before student testing, data collectors received one to two-hours of direct training on administering and scoring CBM-W and CBM-R measures, as well as opportunities for practice and feedback. In this process, data collectors had to demonstrate 90% and 95% fidelity of CBM-R and CBM-W administration, respectively, for each measure. CBM-W administration fidelity was measured by a percentage of checklist items completed correctly on modified, measure-specific CBM forms (Fuchs et al., 1984; Appendix C). For CBM-R, percentage of items completed correctly was measured by the FastBridge Observing and Rating Administrator Accuracy Form (see Appendix D). During screening and pretesting, based on two student recordings, average administration fidelity ranged from 98.0 to 99.0% for CBM-W, and 94.0 to 96.6% for CBM-R.

Also before student testing, data collectors needed to reach 85% and 90% inter-scorer agreement. Inter-scorer agreement was calculated as the number of agreements for each scoring procedure divided by the number of agreements plus disagreements, multiplied by 100 for a percentage correct. During screening, pretesting, and posttesting, data collectors provided 10% of their scored student samples for inter-scorer agreement. Average CBM-W scoring reliability ranged from 84.2 to 100.0% across testing timepoints, measures, and scoring procedures, and average CBM-R scoring reliability ranged from 95.9% to 98.1% across testing timepoints and measures. For administration fidelity and scoring reliability for CBM-R, see Table 5; for CBM-W, see Table 6.

Writing Instruction Fidelity. During teachers' DBI implementation, writing instruction fidelity was measured twice (fall and winter). Writing instruction fidelity was observed and measured using a checklist of steps for implementation of components of explicit and intensive writing instruction (e.g., modeling, guided practice with feedback, independent practice). The measure also captures student participation in instruction (e.g., on-task behavior). Teachers received points for each step on a scale of 0 (not observed) to 2 (fully observed). During training, PIs reviewed each step of the fidelity form with GRAs and provided examples of what type of observed actions may yield each score. GRAs then viewed and scored two sample videos of instruction, once collaboratively and once independently, and received feedback on accuracy from PIs. GRAs needed to reach 80% interobserver agreement (IOA) with PIs before they could score teacher participant fidelity. Writing instruction IOA was calculated as the number of agreed checklist step scores divided by agreements and disagreements, multiplied by 100 to obtain a percentage. IOA observations were conducted by GRAs with other GRAs' writing

instruction observations, either in-person or from video recordings. IOA was calculated based on 20% of each GRAs' observations. Average IOA was 87.4% (range = 79.0 to 95.0%).

DBI-TLC Implementation

Learning Modules and Coaching. Treatment teachers participated in two training modules (Module 1 and 2) in August before school began. These modules provided an overview of DBI, CBM-W, and writing intervention. After student screening and pretesting, teachers attended Module 3, where they chose a CBM task and scoring protocol for each student based on their writing performance and created lesson plans individualized to their students' needs. After creating lesson plans, teachers began implementing writing instruction. At this time, teachers also began collecting CBM data. About 8 weeks into the study, they participated in Module 4, where they learned the process of DBDM using student CBM graphs. During the study, GRAs also provided bi-weekly coaching with problem-solving support, as well as CBM administration fidelity feedback twice, monthly CBM scoring reliability checks, and monthly writing instruction fidelity feedback.

Intensive Writing Instruction. Teachers delivered instruction and collected weekly student CBM-W data across 20 weeks from September to April (not including breaks). Before instruction, treatment teachers created individualized writing instruction plans by selecting from 12 researcher-created Early Writing Project activities, or "mini-lessons" (see Appendix E for lesson titles and descriptions). These mini-lessons targeted transcription (e.g., spelling) or text generation (e.g., sentence construction) skills. Treatment teachers created one to four writing instruction plans (WIPs) for 48 treatment students (all but one treatment student completing the study), depending on how many instructional changes were needed. Students most commonly received instruction targeting transcription skills only (n = 34; 70.8%), followed by a

combination of transcription and text generation skills (*n* = 14; 29.2%). Word Building, a lesson in which students spelled words from basic word stems, was the most commonly implemented mini-lesson (*n* = 46; 95.8%). The percentage of students receiving each skill varied by grade level, with first- and second-grade students more often sublexical-related minilessons, such as Phonics Warm-Up and Alphabet Practice (92.3% and 88.5%, respectively), than third- to fifth-grade students (50.0% and 50%, respectively). For the percent of treatment students receiving each mini-lesson, see Table 7. Thirty-five treatment teachers (71.4%) responded to a posttest survey of their reading and writing intervention practices for each of their students (see Appendix F). They reported providing spelling (88.6%) and handwriting (85.7%) instruction in the context of the Early Writing Project (see Table 8 for writing intervention skills reported by all surveyed teachers).

Early Writing Project researchers recommended that treatment teachers provide instruction at least three times per week in 20-to-30-minute sessions, but teachers ultimately decided intervention dosage. Based on dosage information reported in WIPs, treatment students received approximately 37.3 hours of data-based writing instruction on average. In the posttest survey, treatment teachers similarly reported that treatment students (*n* = 32) received an average of 37.2 hours across 20 weeks (*SD* = 11.7).

Teachers evaluated students' graphed CBM-W data at one to three decision-making time points (after teachers had collected eight weeks of initial data points, and then every four to six subsequent data points). If a student's graphed trend line was flatter than their goal line, teachers made an instructional change. At one or more decision time-points, 28 treatment students (54.0%) received an instructional change, and 19 of those students (67.9%) received intensified

writing instruction as an instructional change. Teachers also opted to increase instructional fidelity (n = 9; 32.1%), and/or change lesson content (n = 1; 3.6%).

Control Writing Instruction. Control teachers implemented a variety of writing instruction for their students. In the posttest survey, 20 teachers reported on instruction provided to 24 control students. As with treatment students, spelling was the most commonly targeted skill (n = 12; 60%); however, so was mechanics (n = 12, 60%). Control teachers also reported providing 33.8 hours of writing intervention, on average, across 20 weeks (SD = 16.5). Differences in writing intervention dosage by experimental condition were not significant (p = 0.38).

Reading Intervention. In addition to writing instruction, surveyed teachers reported that 30 treatment students (85.7% of treatment students in survey) and 16 control students (80.0%) received reading intervention as part of their educational programming. The most commonly targeted skills were decoding for treatment students (100.0%) and phonemic awareness for control students (93.8%; for all skills targeted, see Table 9). Treatment students received, on average, 40.0 hours (SD = 20.9) of reading intervention across 20 weeks. Control students received, on average, 24.9 hours (SD = 17.9) of reading intervention across 20 weeks. Differences in reading intervention dosage by experimental condition were significant ($p < 0.01$). This finding should be interpreted with caution, however, given that a considerably smaller portion of control teachers completed the survey than did treatment teachers.

Fidelity of Teacher DBI Implementation. GRAs monitored treatment teachers' DBI fidelity (writing instruction, CBM, and DBDM). Teachers' fidelity of writing instruction averaged at 90.2% (range = 81.0% to 100.0%) at Time 1 (fall 2021) and 92.6% (range = 77.0% to 100.0%) at Time 2 (winter 2022). Teachers' average CBM-W administration fidelity ranged,

across measures, from 97.1% to 97.6% at Time 1, and 93.5% to 100% at Time 2. Average monthly CBM scoring reliability, as measured by point-by-point agreement between teachers' CBM scoring and their coaches' scoring, ranged from 96.0% to 100.0% across months. DBDM fidelity, as measured by a percentage of two implementation dimensions (timeliness and appropriateness of the decision), averaged at 86.8% at Time 1 (early winter; n = 19 teachers) and 83.3% at Time 2 (early spring; n = 12 teachers).

Data Analysis

Missing Data

For a description of missing student data, please see the Setting and Participants, Students section. Students who were eligible for the study and completed pretest but not posttest reading measures were excluded from analyses using listwise deletion, as this information was needed to examine the effect of the intervention.

Research Question 1: To What Extent Do Elementary Students with Significant Writing Difficulties Also Experience Foundational Reading Difficulties?

This investigation of students' co-occurring reading difficulties was established post-hoc, meaning that I did not intend to identify students with and without reading difficulties before designing the study procedures. However, given that students without foundational reading difficulties may not experience treatment effects on reading outcome measures, the results of this research question may influence interpretation of research questions 2 and 3. Thus, the purpose of research question 1 was to describe the reading needs of the current sample of students. I used LS and DW pretest data (collected at the time of screening) from student participants, who were identified as having significant writing difficulties using eligibility criteria described in the Setting and Participants section. I operationally defined "reading difficulty" differently

depending on student grade level. For first grade students, I used FastBridge LS and DW Fall, 1st Grade benchmark scores (FastBridge Learning, 2022) for "some risk" (LS, <3 CLSPM; DW, 0 CWPM) and "high risk" (LS, 0 CLSPM; DW, 0 CWPM). Unfortunately, as these reading measures are intended for first grade, FastBridge benchmarks for Grades 2-5 do not exist. Instead, I defined reading difficulty for these students as scoring below the Spring, 1st Grade benchmarks for "some risk" (LS, < 41 CLSPM; DW, < 10 CWPM) or "high risk" (LS, < 27 CLSPM; DW, < 4 CWPM).

It is important to note that, because LS and DW benchmarks do not exist for Grades 2-5, the number of students in these grades experiencing foundational reading difficulties could be inaccurately estimated. Additionally, given that different methods were used to identify writing difficulties for the RCT (teacher report and relative writing performance in comparison to research participant peers), students' level of writing and foundational reading difficulty are not comparable or equivalent.

In addition to reporting this descriptive information related to foundational reading difficulty, I also reported the correlations between CBM-R and CBM-W measures and scoring procedures, to examine whether difficulties in one domain are associated with the other.

Preparation for Examining Study Effects

Power Analysis. I estimated the power for this analysis using Optimal Design 3.01. Based on previous studies on the effect of writing interventions on elementary students' letter sound knowledge (Graham et al., 2002; Sénéchal et al., 2012) and word reading (Sénéchal et al., 2012; Berninger et al., 2002a; Fuchs et al., 2006), I anticipated minimum effect sizes of 0.60 *SD* and 0.38 *SD* for letter sound knowledge and word reading, respectively. To detect this effect at power = .80, and at an alpha level of .05 and a teacher-level ICC of .15, and assuming three

students per teacher, 34 teachers would be needed to detect an effect on letter sound knowledge. Eighty teachers would be needed to detect an effect on decodable word reading. I therefore concluded that the current study is potentially sufficiently powered to detect an effect on students' letter sound knowledge, but not decodable word reading.

Pretreatment Analyses. Descriptively, pretest scores for DW CWPM differed considerably between treatment (M = 14.80, SD = 16.8) and control (M = 21.53, SD = 22.06) students, despite random assignment at the teacher level. An independent t-test indicated that these scores did not differ significantly by experimental condition (t = 1.34, p = 0.19); however, the effect size was g = 0.34, indicating that What Works Clearinghouse (WWC) standard for baseline equivalence was not met and a statistical adjustment was needed (WWC, 2022). WWC considers regression covariate adjustments using pretest scores as an acceptable statistical correction for baseline equivalence. Pretest DW CWPM was an intended dependent variable in the models predicting posttest DW CWPM, and thus served as the statistical adjustment.

Hierarchical Linear Modeling. I used hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) to estimate the effects of early writing intervention on students' reading outcomes and determine whether grade level or reading performance at pretest predicted effects. HLM accounts for the clustering of students within teachers' caseloads/classrooms (Osborne, 2000). Models were constructed using the lme4 package (Bates et al., 2015). For both CBM-R measures at posttest, I created a base model that included a random effect of teachers and calculated the intraclass correlation (ICC) to determine the proportion of variance for each posttest CBM-R measure that was attributable to teacher clusters. The ICCs were 0.36 for LS CLSPM and 0.52 for DW CWPM, indicating that a substantial amount of the variance in each CBM-R measure was between teachers, therefore making use of HLM tenable (Hox et al., 2010). An important

note is that these ICCs are considerably higher than the ones I used to estimate power; thus, it is possible that even more teachers would be needed than originally estimated to detect effects in this study. Experimental condition was coded as treatment = 1 and control = 0. Grade was a continuous variable, as were CBM-R pre- and posttest scores.

Research Question 2: What is the Effect of Data-Based Writing Instruction on the Foundational Reading Outcomes of Students with Significant Writing Difficulties?

The model for research question 1 was follows, with one model for each CBM-R outcome (posttest LS CLSPM and DW CWPM):

$$Y_{ij} = \gamma_{00} + \gamma_{01} Experimental\ Condition_{ij} + u_{0j} + r_{ij}$$

where Y_{ij} is the posttest CBM-R score of student *i* nested in teacher (classroom or caseload) *j*, γ_{00} is the mean posttest CBM-R score for students of control teachers, γ_{01} is the mean posttest CBM-R score difference between treatment and control groups, u_{0j} is the random effect of teacher *j* on the mean posttest CBM-R score when holding experimental condition constant, and r_{ij} is the student-level residual.

Research Question 3: Are the Effects of Data-Based Writing Instruction Predicted by Students' Pretest Reading Scores and Grade Level?

For research question 3, I used a model comparison approach to test the statistical significance of sequentially more complex models for each reading outcome. The experimental condition-only models from research question 2 served as the base models for each CBM-R outcome (Model 1). Subsequent models (Model 2 to Model 4) added fixed effects, pretest CBM-R score and grade level. The sample size of the current study was not sufficient to include random effects in addition to teacher intercept, as models with random intercepts and slopes for pretest CBM-R and grade level failed to converge. However, due to the potential that students

with higher pretest reading scores would not experience added benefit from intensive writing instruction (e.g., Kim, 2022), and the converse potential for Matthew effects (Stanovich, 1986), I included an interaction term for pretest CBM-R scores and experimental condition. Thus, the equation for the most complex model for each CBM-R outcome was as follows:

$$Y_{ij} = \beta_{0j} + \beta_{1j}Pretest\ CBM\text{–}R\ Score_{ij} + \beta_{2j}Grade\ Level_{ij} + \beta_{3j}Experimental\ Condition + \beta_{4j}(Pretest\ CBM - R\ Score \times Experimental\ Condition)_{ij} + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

$$\beta_{4j} = \gamma_{40} + u_{4j}$$

where Y_{ij} is the posttest CBM-R score of student *i* nested in the classroom/caseload of teacher *j*, γ_{00} is the mean posttest CBM-R score, u_{0j} is the random effect of teacher *j* on the mean posttest CBM-R score, γ_{10} is the mean pretest-posttest CBM-R slope, u_{1j} is the random effect of teacher *j* on the mean pretest-posttest CBM-R slope, γ_{20} is the mean grade level-posttest CBM-R slope, u_{2j} is the random effect of teacher *j* on the mean grade level-posttest CBM-R slope, γ_{30} is the mean difference between control and treatment students' posttest CBM-R scores, u_{3j} is the random effect of teacher *j* on the mean difference between control and treatment students' posttest CBM-R scores, γ_{40} is the mean effect of pretest CBM-R scores on the difference in posttest CBM-R scores between treatment and control groups, and u_{4j} is the random effect of teacher *j* on this interaction.

I used two model indices to determine improvement in fit: likelihood ratio (χ^2) and corrected Akaike information criterion (AICc). I used the delta AICc to determine the relative empirical support for the model of best fit in comparison with the next-best fitting model. A delta AICc value less than 2.0 indicated that an alternate model was also plausible (Burnham et al., 2011). Model comparisons served as omnibus tests for the parameters of each model.

Visual inspection of scatterplots of posttested CBM-R scores with pretest CBM-R scores and grade indicated that the assumption of linearity was tenable. I examined the tenability of the assumption of normality using density plots of level 1 (fixed effect) and 2 (random effect) residuals for each CBM-R model of best fit. I examined the tenability of the homoscedasticity assumption using a scatterplot of the fitted values versus the level 1 residuals, also from the models of best fit.

Chapter 4: Results

Research Question 1: To What Extent Do Students with Significant Writing Difficulties Also Experience Foundational Reading Difficulties?

A notable percentage of student participants experienced co-occurring difficulties in letter sound knowledge and decodable word reading before the intervention, as determined by FastBridge first grade benchmarks for LS CLSPM and DW CWPM. However, the percent of students experiencing reading difficulties varied by grade and reading measure (see Table 10). In total, 62.8% and 30.0% of students were at "some" or "high risk" for difficulties in letter sound knowledge and decodable word reading, respectively. No first graders were at some or high risk for letter sound difficulties; in contrast, 48.84% of second graders were at high risk, as were 29.63% to 36.84% of students in Grades 3 to 5. For decodable word reading, 55.56% of first graders were at some risk, and none were at high risk. The percent of students at risk decreased across Grades 2 to 5, from 36.4% to 0%.

Students' LS CLSPM and DW CWPM scores were moderately ($0.4 \leq r > 0.6$) to strongly ($r < 0.6$; Akoglu, 2018), and significantly ($p \leq 0.05$) correlated with most writing scores across lower and upper elementary grade levels (Grades 1-2 and 3-5); however, some variations by grade level and writing skill occurred (see Table 11). Interestingly, for first and second graders, the correlations of LS CLSPM with Word Dictation scores (words written, words spelled correctly, and correct minus incorrect letter sequences) were stronger ($r = 0.64$ to 0.72) than the correlation between LS CLSPM and DW CWPM ($r = 0.34$). For upper elementary students, the same pattern occurred for correlations between DW CWPM and Word Dictation scores ($r = 0.62$ to 0.79) versus DW CWPM and LS CLSPM scores ($r = 0.46$). Across grades, LS CLSPM and DW CWPM were also moderately to strongly correlated with Picture Word and Story Prompt

words written and words spelled correctly (r = .41 to .79), as well as the KTEA-3 Written Expression scale of the Written Language subtest (r = .51 to .59). Correlations between reading measures and Story Prompt CIWS were weak (r = -.39 to .13); however, so were the correlations of Story Prompt CIWS with other writing measures (r = -.43 to .27). A notable difference in reading-writing connections for lower and upper elementary grades was that LS CLSPM and Word Dictation score correlations were strong only for lower elementary students.

Research Question 2: What is the Effect of Data-Based Writing Instruction on the Foundational Reading Outcomes of Students with Significant Writing Difficulties?

For reading pre- and posttest means and standard deviations overall and by grade, see Table 12. The effect of treatment on students' posttest LS CLSPM scores was positive, but not significant (γ_{01} = 2.25, p = 0.61). The effect of treatment on DW CWPM scores was negative, but not significant (γ_{01} = -2.60, p = 0.70).

Research Question 3: Are the Effects of Data-Based Writing Instruction Predicted by Students' Pretest Reading Scores and Grade Level?

Given that experimental condition alone was not a significant predictor of students' posttest CBM-R scores (Model 1), I created alternative models that included only pretest CBM-R scores and grade level as predictors (Models 2 and 3). The purpose of creating these alternative models was to evaluate whether the presence of the experimental condition predictor improved model fit over these potentially stronger predictors. In subsequent models, I added experimental condition back in as a predictor. Results of model comparisons for each CBM-R outcome are outlined below.

Letter Sounds, Correct Letter Sounds Per Minute as an Outcome

The correlation between the two continuous predictors in models predicting posttest LS CLSPM, grade level and pretest LS CLSPM, was weak and non-significant ($r = 0.16$, $p = 0.11$). For the taxonomy of models, see Table 13. Model 3, which included students' pretest LS CLSPM scores and grade but not experimental condition as predictors, fit the data best. The delta AICc between Model 3 and Model 4 was 1.29, indicating that this model may have also been plausible. However, the likelihood ratio was only significant for Model 3 ($\chi^2 = 7.13$, $p \leq 0.01$); thus, Model 3 demonstrated sufficient evidence to suggest best fit.

In Model 3, a 1-point increase in LS CLSPM at pretest was associated with a 0.82-point increase at posttest, when controlling for grade level and the random effect of teacher intercept ($p \leq 0.001$). Furthermore, each additional grade was associated with a 2.99-point decrease in posttest LS CLSPM scores when controlling for pretest LS CLSPM scores ($p \leq 0.01$). The model assumptions of normality and homoscedasticity were met (see Figure 2).

Decodable Words, Correct Words Read Per Minute as an Outcome

Density plots of the level 1 residuals of the DW CWPM model of best fit indicated that, likely due to the right-skew of DW CWPM pre- and posttest scores (see Figure 3), the model assumptions of normality and homoscedasticity were not met (see Figure 4 for plots). To address these potential model assumption violations, I added a constant of 1 and log-transformed DW CWPM pre- and posttest scores. Updated plots indicated that both the normality and homoscedasticity assumptions were tenable (see Figure 5).

Log-transformed pretest DW CWPM scores and grade level were moderately and significantly correlated ($r = 0.46$, $p \leq 0.001$). As a result, models including both DW CWPM log-transformed pretest scores and grade level as predictors resulted in singular fits, meaning that the

relation led to random effect estimates of zero. To address this multicollinearity, I created two sets of candidate models including grade level or pretest scores. All models that included pretest scores outperformed models including grade level in terms of AICc; thus, I selected pretest scores as a predictor.

Results from the taxonomy of log-transformed DW CWPM models are reported in Table 14. Model 3, which included log-transformed pretest DW CWPM and experimental condition as predictors, demonstrated the strongest evidence of fit. Although Model 2 was also plausible (delta AICc = 1.73), the likelihood ratio was significantly higher for Model 3 ($\chi^2 = 3.94$, $p \leq 0.05$). The final, fitted, exponentiated equation for the fixed effects was as follows:

$$\widehat{Post\ DW\ CWPM}_{ij} = e^{1.02 + 0.77 \times \ln(Pre\ DW\ CWPM_{ij}) + 0.23(Experimental\ Condition_{ij})}$$

The exponentiated intercept indicated that the estimated posttest DW CWPM score for control students with a score of 1 at pretest was 2.78. The coefficient for log-transformed pretest DW CWPM, 0.77, indicated that for every 1% increase in pretest DW CWPM score, posttest DW CWPM scores increased by 0.77% when controlling for differences in experimental condition ($p \leq 0.001$). Applying a correction for dichotomous predictors (Halvorsen & Palmquist, 1980), the exponentiated coefficient for experimental condition, 0.23 (95% CI [1.13, 1.33]), indicated that treatment students had a predicted posttest DW CWPM score that was 1.26 times, or 25.9% higher than, the estimated score for control students when controlling for differences in pretest scores ($p \leq 0.05$). The fitted equation for control students was as follows:

$$\widehat{Post\ DW\ CWPM}_{ij} = e^{1.02 + 0.77 \times \ln(Pre\ DW\ CWPM_{ij})}$$

The fitted equation for treatment students was as follows:

$$\widehat{Post\ DW\ CWPM}_{ij} = e^{1.25 + 0.77 \times \ln(Pre\ DW\ CWPM_{ij})}$$

The final model was a conditional growth model, meaning that there was a differential effect of treatment as a result of how the multiplicative relation between log-transformed DW CWPM pre- and posttest scores functioned for students in control and treatment groups. To illustrate, a control student with a pretest DW CWPM score of 18.39 (the full sample mean) was estimated to have a posttest score of 26.04, whereas a treatment student with the same pretest score was estimated to have a posttest score of 32.79 (a 6.75-point, or 25.9%, difference between experimental groups). Alternatively, for students who scored one point on DW CWPM at pretest, estimated posttest scores were 2.78 for control students and 3.44 for treatment students (a 0.72-point, or 25.9%, difference). For a plot of the fitted regression lines, see Figure 6.

It is important to note that, although the back-transformed regression lines are non-parallel, there was no interaction term for log-transformed pretest and treatment in the final model, Model 3. Pretest scores did not influence the difference in percent change in posttest scores between treatment and control students (Shang et al., 2017; Wooldridge, 2016). Therefore, pretest scores can be described as a logarithmic predictor, as opposed to a moderator, and the effect of treatment can be generally described as conditional based on pretest scores.

To determine whether a similar effect of pretest occurred on the intended outcome of the Early Writing Project, writing, I fit equivalent candidate models with Word Dictation correct minus incorrect letter sequences posttest scores as the outcome and Word Dictation correct minus incorrect letter sequences as the pretest predictor. I found that the model of best fit, which is not representative of the overall effects of the three-year Early Writing Project, included a positive and significant interaction term between Word Dictation correct minus incorrect letter sequences and experimental condition ($\beta_{4j} = 0.43$, $p \leq 0.01$), indicating that variation in

treatment effects as a function of pretest scores was consistent between DW CWPM and this writing skill.

Chapter 5: Discussion

The purpose of this RCT was to examine the effect of data-based writing instruction on foundational reading outcomes (letter sound knowledge, decodable word reading) of elementary students with significant writing difficulties. I found that a considerable portion of elementary students with significant writing difficulties also may have experienced reading difficulties in letter sound knowledge and decodable word reading based on first grade benchmarks. Additionally, these two foundational reading skills were related to a variety of writing skills across grade levels.

Data-based writing instruction alone did not lead to statistically significant positive effects on letter sound knowledge or decodable word reading. For letter sound knowledge, students with higher pretest scores and in lower grade levels experienced better outcomes. Treatment students did perform significantly higher on decoding (25.9% higher scores compared to controls) when I accounted for the positive, multiplicative effect of students' decodable word reading skills at pretest. Implications of these findings and directions for practice and future research are outlined below.

Connections Between Elementary Reading and Writing Difficulties

The significant, moderate to strong correlations between letter sound knowledge, decodable word reading, and writing measures provide empirical support for the theory that reading and writing develop from shared linguistic skills (Berninger & Abbott, 2010; Berninger et al., 1996; Berninger et al., 1997; Kim, 2020). In particular, these relations suggest that sublexical- and lexical-level reading skills are related to lexical- and sentence-level writing skills, namely spelling, sentence production, and written output. The correlations in the current

study cannot, however, demonstrate the extent to which student participants experienced co-occurring reading and writing difficulties.

Although firm conclusions cannot be reached, two pieces of converging evidence suggest that most students in this study experienced co-occurring reading and writing difficulties. First, the percentage of students experiencing foundational reading difficulties, as evidenced by first-grade reading benchmark scores, tentatively suggests that reading was a challenge for a notable portion of the sample. Second, in the posttest survey described in the methods chapter of this dissertation, most teachers reported that their students received supplemental small-group reading interventions, suggesting that most students required support in one or more reading skills. Taken together, these findings allow us to speculate, but not conclude, that students in the sample experienced reading difficulties that were connected to their writing difficulties. Such findings would be consistent with research indicating that reading and writing difficulties are connected in early elementary grades, and continue throughout elementary grades (Costa et al., 2016; Thomas et al., 2020).

These reading-writing relations also provide additional empirical support for the IDLM. A strong corpus of research suggests that decoding difficulties are connected to handwriting and spelling difficulties (Barth et al., 2010; Bishop et al., 2009; Carroll & Breadmore, 2018; Curtin et al., 2001; Duff et al., 2012; Kim et al., 2013; Komesidou, 2018; Sumner et al., 2016), and can in fact predict these difficulties across elementary grades (Clemens et al., 2014; Garcia et al., 2010). However, letter sound knowledge has been studied relatively less frequently; thus, the moderate to strong relations between letter sound knowledge and writing skills extend current knowledge to suggest that one of the earliest reading skills students acquire is connected to writing. These correlations also provide some support for the hierarchical relations between foundational

reading and sentence-level writing skills. Relations between decodable word reading and Word Dictation, Picture Word, and Story Prompt words written scores corroborated connections between decoding and written output difficulties demonstrated in previous research (Sumner et al., 2016). Furthermore, the positive correlations in the current study cover a broader span of the hierarchy, from letter sound knowledge to written expression. However, given that this evidence is correlational, this relation could be moderated by third variables, such as the cognitive processes that directly and indirectly affect both higher- and lower-level literacy skills (e.g., Ahmed et al., 2014, 2022; Kim et al., 2020). Future path analyses for a similar population of students may yield interesting conclusions regarding the moderators and directions of such effects.

The finding that reading and writing connections were substantial in both lower- and upper-elementary grades supports the hypothesis that reading-writing relations are dynamic both in terms of students' age and foundational literacy needs (Kim, 2022). Theory and empirical research suggest that for upper elementary and/or advanced readers and writers, lexical-level skills become more automatized, and relationships are stronger between text comprehension and composition (Berninger et al., 2002b; Shanahan, 1984). Comparisons between LS and DW with first-grade benchmarks tentatively suggest that a notable portion of students in grades 3 to 5 in this sample had not yet developed these automized lexical-level skills. Yet, the strength of correlations was not identical for younger and older students, suggesting that age, in addition to skill, influenced connections. Despite these variations, the overarching pattern of shared lexical-level skills across lower- and upper-elementary students with writing difficulties is consistent with previous research (Barth et al., 2010; Carroll & Breadmore, 2018; Curtin et al., 2001; Duff et al., 2012; Kim et al., 2013; Komesidou, 2018; Sumner et al., 2014; Thomas et al., 2020).

Effects of Data-Based Writing Instruction, Initial Reading Skill, and Grade on Reading Outcomes

I hypothesized that data-based writing instruction would have a small but positive effect on reading outcomes, but this effect would vary depending on students' level of reading difficulty and grade. As discussed previously, findings tentatively suggest that most students did experience reading difficulty, and thus their placement on a continuum of reading scores, as opposed to membership to distinct reading-writing difficulty profiles, predicted treatment effects. HLM results did not indicate that DBI for writing had a positive effect on letter sound knowledge, and indicated an effect of DBI for writing on decoding that was conditional on pretest scores. In the following sections, I discuss the varying effects of treatment by reading outcome, and the role that grade and/or initial reading skill played in predicting outcomes.

Lack of Effect of Data-Based Writing Instruction on Letter Sound Knowledge

Data-based writing instruction did not have a significant positive effect on students' letter sound knowledge, even after controlling for pretest scores and grade level. First, this analysis was potentially underpowered to detect an effect of writing instruction on letter sounds; although the ad-hoc power analysis indicated the study was sufficiently powered to detect this effect, the teacher ICCs were higher than originally estimated. This lack of effect is consistent with my meta-analysis in preparation (E. Shanahan, 2023), which indicated that effects of writing instruction on the letter sound identification of elementary students with literacy difficulties was not significant (k = 7; g = 0.09, 95% CI [-0.07, 0.24]). Nonetheless, these non-effects of treatment are not consistent with theory suggesting that highly interrelated foundational reading and writing skills can be capitalized on through cross-domain instruction, particularly for beginning readers (Shanahan, 1984).

The negative relation between grade and posttest LS CLSPM in the final model suggests that older students, regardless of treatment condition, did not experience as much pre- to posttest growth in letter sound knowledge as compared to younger students. First grade is a period of rapid letter sound knowledge development (Ehri & Wilce, 1987), so this finding is not necessarily unexpected. The simplest explanation would be that students in upper elementary grades had already reached a necessary and sufficient "threshold" of letter sound knowledge needed to develop lexical- and sentence-level literacy skills (Ehri & Roberts, 2006). However, given that most third- to fifth-grade students met "risk" criteria based on first grade spring LS CLSPM benchmarks, it is still possible that these students could have benefitted from growth in letter sound knowledge to promote further literacy development.

If students could have benefitted from letter sound knowledge support, an alternative explanation for the lack of treatment effect is that the treatment did not target grapheme-phoneme relations in a way that promoted this outcome. In the literature review of this dissertation, the one study that included letter sound writing for students with literacy difficulties resulted in positive effects on reading (Vaughn et al., 2006). Although teachers in the current study who provided handwriting-related mini-lessons were directed to reinforce the names of the letters being written (e.g., Alphabet Practice), whether letter sounds were reinforced was up to the discretion of the teacher. Given the paucity of research investigating the effects of writing interventions on students' letter sound knowledge across elementary grade levels, future experimentation is needed.

Conditional Effect of Data-Based Writing Instruction on Decodable Word Reading

Data-based writing instruction did have a positive effect on students' decodable word reading that was conditional on pretest reading scores. Both spelling instruction (ES = 0.40;

Graham & Santangelo, 2014) and broader writing instruction (ES = 0.62; Graham & Hebert, 2011) have been found to positively influence word reading, and these positive effects hold for elementary students with literacy difficulties, albeit to a lesser extent ($g = 0.29$, 95% CI [0.22, 0.35], $p \leq 0.001$; E. Shanahan, 2023). The findings from the current study are consistent with and extend this knowledge by suggesting that data-based writing instruction in particular, which is individualized to elementary students' writing needs, can also support decoding, but only for students with more decoding skill.

This finding also builds on existing knowledge regarding the effects of writing intervention on reading outcomes. First, in the literature review chapter of this dissertation, I found that writing interventions for students with reading difficulties were delivered at a considerably lower dosage than reading plus writing (RPW) interventions, which made comparisons between the effects of writing and RPW interventions on reading outcomes more difficult. In this study, DBI was delivered at a relatively high dosage, thus improving the evidence base required to evaluate the relative effects of these two types of interventions on reading. Second, previous studies have often focused on how spelling interventions in particular can support word reading (e.g., Graham et al., 2002). Many teachers in this study implemented multi-component writing instruction, which is theorized to be more effective in increasing reading outcomes (Hebert et al., 2022). Among these components were mini-lessons targeting written syntax (e.g., Sentence Construction), a skill that was not yet investigated as a facilitator of reading outcomes, according to my literature review. Last, I identified no writing intervention studies examining the effects on reading that used DBI in my literature review or my meta-analysis (E. Shanahan, 2023), suggesting that the current study is the first demonstrating promise for the utility of DBI for this cross-domain treatment and outcome.

When considering the implications of this positive treatment effect, it is critical to note that students who started DBI with the strongest decoding abilities experienced the strongest treatment effects over control students, whereas treatment students who required the most decoding support did not experience meaningful improvements over control students. DBI is intended to support students with the most intensive learning needs (Deno & Mirikin, 1977; National Center on Intensive Intervention, 2013). Thus, the fact that students with the most intensive decoding needs amongst a pool of students who already experienced significant writing difficulties were not supported by DBI is cause for concern.

The effects initial decodable word reading skill on treatment effects resembles a Matthew effect, initially proposed by Stanovich (1987), in which students with higher reading skills at the beginning of an intervention experience greater benefit. All students in this study experienced writing difficulties and many experienced reading difficulties; therefore, this differential treatment effect is not completely analogous to the original definition of Matthew effects, but a similar phenomenon may have occurred. Stanovich's initial, empirically-grounded hypothesis was that Matthew effects were caused by the fact that students with lower initial reading skills were not prepared to make noticeable gains on higher-level outcomes of interest. However, if this source were the sole cause of Matthew-like effects on decoding for the current sample, we may have anticipated seeing a positive effect of treatment on letter sound knowledge. Alternatively, Stanovich proposed that Matthew effects could result from lack of alignment between foundational skill need and intervention activities. Yet, the majority of treatment students received instruction targeting lexical-level skills, and treatment teachers monitored whether mismatches between writing instructional content and students' instructional needs occurred through DBDM.

Although it is still possible that these two phenomena, too-advanced outcomes and too-advanced instruction, may have resulted in a Matthew-like effect in this study, a third potential explanation is that students with the most decoding difficulty required more intensified, individualized instruction than what treatment teachers could provide. Teachers have reported experiencing multiple sources of school-level barriers to effective intensification of instruction for students who are not making expected progress in DBI (E. Shanahan et al., 2023). It is possible that teachers in this study experienced similar difficulties. For example, a teacher may have identified that their student would benefit from instruction delivered in a smaller group, but constraints on school staffing made this intensification impossible. Teachers may have been even less able to provide effectively individualized interventions as a result of COVID-19-related barriers, which have been found to negatively impact the literacy growth of elementary students with disabilities to a greater extent than those without disabilities, even during in-person instruction (Relyea et al., 2023).

Limitations

The implications of these findings must be considered in light of several limitations. The first set of limitations is related to the nature of the LS and DW measures. FastBridge does not have normed benchmark scores for LS and DW measures in grades 2 to 5; thus, the proportion of these students I described as potentially having foundational reading difficulties, based on spring first grade benchmarks, was likely underestimated. I was unable to find reliability or validity evidence for LS and DW for grades 2 to 5, which could have resulted in imprecise or low-utility measurement. Criterion validity with a distal, norm-referenced reading measure may have provided evidence for or against letter sounds or decoding being meaningful learning targets for upper-elementary students.

Second, while all schools had returned to in-person instruction at the time this intervention was conducted (2021-2022 school year), the continued effects of the COVID-19 pandemic may have influenced data-based writing instruction implementation. There was substantially higher treatment teacher attrition than control teacher attrition, potentially because teachers needed to balance new, competing priorities for instructional and planning time, such as a focus on supporting students' social behavior after a year of relative isolation. Additionally, whether excessive absences occurred, and whether those absences were due to quarantining, was unclear. If this was the case, the extent to which students received the high dosage of writing instruction that teachers originally planned may have been affected. These potential implementation issues could have influenced the magnitude and precision of treatment effect estimates.

Third, there were comparatively few fifth graders in the sample; as a result, estimates of the effect of grade level on reading outcomes may have been inaccurate due to lack of data. Fourth, among the subsample of teachers who completed a posttest survey, treatment teachers reported providing significantly higher doses of reading intervention than did control teachers. These differences should be interpreted with caution, given that only about a third of control teachers responded to the survey; however, it is possible that treatment students receiving more reading intervention time could explain the apparent positive effect of treatment on decodable word reading outcomes.

Directions for Future Research

Most students in this study likely experienced co-occurring reading and writing difficulties; future research with larger samples is necessary to determine whether distinct profiles of elementary students experiencing foundational reading and/or writing difficulty can

be identified. Reading and writing are not perfectly reciprocal skills (Shanahan, 2016); as a result, not all elementary students with writing difficulties experience reading difficulties (Costa et al., 2016). Alternative sources of writing difficulty that may occur independently of linguistic knowledge include fine motor difficulties (e.g., Deuel, 1994) and difficulties with attention (e.g., Adi-Japha, 2007). Students who experience independent writing difficulties would likely benefit more from (1) writing interventions that explicitly target these areas of need (e.g., handwriting support or self-regulated strategy development; Santangelo & Graham, 2016; Sun et al., 2022), and (2) high-quality, research-based Tier 1 reading instruction. Researchers have previously identified subgroups of reading comprehenders by selecting clustering solutions that accounted for the most variability in the data, and these subgroups experienced differential effects of reading comprehension interventions (McMaster et al., 2012). Similar methods may be applied to determine whether different foundational literacy profiles exist, and, if so, predict elementary student reading outcomes after participation in a writing intervention.

Moving forward, more precise experimentation on the effects of writing intervention on letter sound knowledge is needed. First, samples of elementary students who specifically struggle with letter sound knowledge, based on grade level benchmarks, should be identified. Then, researchers could evaluate whether writing dictated letter sounds has positive effects on letter sound identification. Writing dictated sounds may serve as a practice opportunity that could reinforce or strengthen understanding of phoneme-grapheme relationships (Graham et al., 2018; Shanahan, 1998). Then, researchers could compare the effect of letter sound writing versus reading-only letter sound instruction on students' letter sound identification, to determine whether writing provides an added benefit.

It is essential to explore whether the Matthew-like effect that might have occurred in this study is replicated in future DBI studies, and, if so, whether these effects are a result of challenges implementing data-based intensification decisions. Researchers have previously suggested the need for increased focus on DBDM in DBI training (Espin et al., 2021). However, teachers in this study did receive PD support in making data-based decisions. Given that DBDM and effective intensification are applied, student-specific processes (e.g., Fuchs et al., 2018), PD may have supported teachers' intensification further with more practice opportunities or more specific feedback. However, before considering how to improve teachers' instruction for students who require intensified support, researchers must first consider ways to alleviate systemic barriers to intensification, such as limited planning and instructional time (E. Shanahan et al., 2023). Recent research has shown that DBI can be implemented effectively with school-wide educator participation (Kearns et al., 2022; Lemons et al., 2019; Powell et al., 2021). Potentially, including other school team members in the DBI process could alleviate some barriers to intensification and result in increased outcomes for students who need intensified academic support.

Directions for Practice

The finding that data-based writing instruction had a conditional effect on decoding among this sample of students has positive implications for instruction, with some additional cautionary measures needed. One notable feature of this study is that student participants included students with and without disabilities, students with a variety of disabilities, and students receiving ELL services who had an additional need for intensive writing support. My literature review revealed that some previous writing interventions excluded students on the basis of student disability or ELL status. Students with disabilities other than learning disabilities, such

as attention deficit hyperactivity disorder, intellectual disabilities, and developmental language disorders, might struggle with both reading and writing and benefit from writing support (Bakken et al., 2021; Graham et al., 2016; Graham et al., 2020). Additionally, many literacy intervention strategies for students who do not need ELL support are similarly effective for the literacy needs of multilingual students working towards English proficiency and also struggle with writing (e.g., Lee and De La Paz, 2021; Silverman et al., 2021; Vaughn et al., 2006). Thus, the recommendations for practice outlined below may support teachers who work with students with diverse learning needs but shared writing and decoding priorities in the same instructional intervention groups.

The conditional effect of DBI for writing on decoding suggests that students may experience supplemental benefit to decoding through writing intervention. For students who struggle with both spelling and decoding, teachers may target decoding with writing activities such as the Word Building mini-lesson, which involves careful attention to spelling patterns within words, their phoneme-grapheme relationships, and opportunities to practice spelling and reading decodable words. Teachers in the current study also included activities targeting other skills on other levels of the IDLM writing hierarchy, such as handwriting and sentence construction, to create multi-component interventions that also led to positive decoding outcomes. Other teachers may therefore be able to successfully incorporate students' other writing needs into shared writing and decoding interventions (Hebert et al., 2022). For example, during intervention activities aimed at improving students' sentence writing, teachers could encourage students to use words from a recently-mastered spelling pattern and then provide feedback on spelling in addition to sentence syntax and mechanics. During shared writing plus

decoding interventions, teachers should make the connections between decoding and writing skills explicit to students (Hebert et al., 2022).

Given that DBI for writing effects were not meaningful for students experiencing the highest decoding needs, additional precautions should be taken to ensure that these students are benefitting from shared writing plus decoding interventions. First, the effects of writing interventions on reading are theorized to not be as strong as the effects of reading intervention, although more research is needed (Shanahan, 2016). Therefore, students who struggle significantly in writing and reading may benefit more from separate reading and writing interventions if time allows. Teachers can individually test this hypothesis with their students by applying the DBI framework. Beginning with a shared reading plus writing intervention, teachers could monitor students' progress in all targeted skills using CBMs to ensure that they are experiencing expected growth. If students are still not making expected growth after appropriately intensifying and individualizing instruction, teachers should provide separate decoding and writing interventions (Kim, 2022).

Although these suggestions for teachers could lead to a positive impact on the decoding and writing outcomes of their students with literacy difficulties, systemic change is needed for widespread integration of reading and writing interventions. Throughout the 20th century, individual teachers in the United States were often tasked with developing their own means of incorporating writing into their classrooms (Shanahan, 2022). This lack of widespread, effective writing instruction was in part a result of greater social, political, and economic value placed on reading (Fitzgerald & Shanahan, 2000; Shanahan, 2016; Shanahan, 2022). The value of writing has evolved this century – it is currently the third most sought-after skill among employers (National Association of Colleges and Employers, 2020). Additionally, with increased

computerized written communication for social interaction and employment (Graham, 2020; Shanahan, 2022), there is little justification for writing to continue to be sidelined. Beyond this utility, it allows individuals to share impactful messages widely and express themselves artistically (hooks, 1994; Lorde & Wylie Hall, 2004). Such expression is particularly meaningful for individuals with disabilities whose educational goals align with verbal and written communication, yet whose voices are often ignored or neglected (de Bie et al., 2019).

Unfortunately, this inherent value has not influenced key decision-makers at state or national levels to ensure that writing is taught effectively to elementary students needing intensive literacy support. Today, students still spend little time writing, and teachers spend little time teaching writing (Graham, 2019; Spear-Swerling & Zibulsky, 2014; Troia et al., 2015). The findings of this and similar studies, which demonstrate the potential value of writing intervention in increasing reading outcomes, may signal to policymakers that steps towards more systemic elementary writing support should be taken, for the sake of this higher-value skill.

A first step may be to conduct a nationwide writing assessment, which elementary students with reading difficulties will ultimately benefit from. The recent NAEP results in reading, which indicated that only 32% of fourth graders and 11% of students with disabilities scored at or above proficient (NCES, 2022), were startling and prompted national discussion on how to address elementary students' reading needs (Jimenez, 2022; Mervosh, 2022). No such conversation could be had about writing, as NCES has not evaluated fourth-grade students' proficiency in over 20 years (NCES, 2003). Thus, the full picture of elementary students' literacy needs is still missing. Additionally, standardized testing has been shown to drive state, district, and school priorities, which influence teachers' instructional capacities and decisions (Shanahan, 2022). It is possible that national attention to writing via standardized assessment will prompt

system-level stakeholders to direct more resources to ensuring that all students receive sufficient writing support.

One of these resources could be providing schools with opportunities to conduct writing screening as part of existing MTSS programs. The correlations between foundational reading and writing skills in this and other studies were sizeable, but not perfect, due to asymmetrical relations (e.g., Ahmed et al., 2022; Kim, 2020). Thus, screening for reading difficulties is not sufficient to determine whether students are receiving the necessary Tier 1, 2, or 3 writing instruction needed to promote literacy development. Once schools use writing screening results to ensure that effective Tier 1 instruction is being delivered, they may identify students in need of more support, and use both writing and reading screening results to create instructional groups of students for whom combined reading and writing intervention may be effective. Teachers who support students with intensive learning needs, who either receive Tier 3 instruction or small-group special education services, may also use writing screening results to identify individual student skill needs and teach to potential areas for mutual literacy development, as previously described. Through this pathway of increased resources for writing, elementary students with significant writing difficulties could consistently have the opportunity to receive efficient and effective data-based literacy instruction.

Conclusion

The purpose of this dissertation was to examine the effects of data-based writing instruction on two foundational reading skills, letter sound knowledge and decodable word reading, for elementary students with significant writing difficulties. I found that, although these reading skills were correlated with sublexical-, lexical-, and sentence-level writing skills, hierarchical linear models did not indicate that data-based writing instruction had independent

positive effects on reading outcomes. However, data-based writing instruction did have a positive, multiplicative effect on decodable word reading when controlling for students' initial decoding skills, meaning that students with higher initial decoding skills experienced greater response to treatment. Future research may explore whether student membership to unique profiles of reading and/or writing difficulties predict treatment effects, investigate the effects of specific letter sound writing interventions on letter sound knowledge, and examine whether and why Matthew effects might occur in DBI. The positive effect on decoding in this study suggests that teachers whose students would benefit from both decoding and writing support could potentially combine aspects of reading and writing interventions. Additionally, this preliminary finding may serve as additional evidence that the merging of reading and writing priorities is justified (Graham, 2020), and that systems-level steps to support writing could lead to better literacy outcomes for students with significant literacy needs.

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Table 1

Literature Review, Characteristics of Writing and Reading/Writing Intervention Studies

Study	Study Design	Type	Reading/ Writing Difficulty	Exclusion Criteria	Student Grades	Group Size	Sessions	Session Length (Min)
Alber-Morgan et al. (2016)	SCED	RW	RA	NR	1	1:1	NR	12.5
Amendum et al. (2011)	RCT	RW	RA	ELL; Severe disability	K, 1	1:1	NR	15
Berninger et al. (1995)	RCT	W	HW	BT IQ; ND	4	1:1	14	60
Berninger et al. (1997)	RCT	W	WF	BT IQ; ELL	1	3:1	24	10
Berninger et al. (2002)	RCT	W	W, NR	NR	3	2:1	24	20
Blachman et al. (2004)	RCT	RW	WR	ASD; BT IQ; EBD; ELL; ID; Left-Handed; SD; SI	2, 3	1:1	~126	50
Case et al. (2014)	RCT	RW	PA; WR; RA	NR	1	2-4:1	25	40
Englert et al. (1991)	RCT	W	RA	BT IQ; EBD; ID; LI	4, 5	NR	NR	NR
Fuchs et al. (2006)	RCT	W	RA	NR	1	1:1	50	10
Georgiou et al. (2021)	RCT	RW	WR	EBD; ID; SD	3	1:1	~60	30
Graham et al. (2002)	RCT	W	Spell	ELL	2	2:1	~72	20
Hatcher et al. (1994)	RCT	RW	WR	Significant ID; Significant reading difficulty; SWD	1	1:1	40	30
Hebert et al. (2018)	RCT	W	PA; WR; RF; RC	NR	4, 5	1-2:1	12	30
Idol & Croll (1987)	SCED	RW	RC	Adequate decoding	2, 4, 5	1:1	NR	NR

Study	Study Design	Type	Reading/ Writing Difficulty	Exclusion Criteria	Student Grades	Group Size	Sessions	Session Length (Min)
Joseph (2002)	SCED	RW	LS; PA; WR	NR	2 to 4	3:1	21	20
Joseph (1999)	SCED	RW	WR; Spell	NR	4, 5	3:1	NR	40
Keesey et al. (2015)	SCED	RW	PA; WR	Unable to isolate initial sounds	K	1:1	15 to 21	20
Lane et al. (2009)	RCT	RW	Spell	NR	1	1:1	40	34
Mason et al. (2013)	RCT	RW	RA; WA	NR	4	NR	18 to 22	30
Rashotte et al. (2001)	RCT	RW	WR	NR	1 to 4	3-5:1	140	50
Senechal et al. (2012)	RCT	W	PA; WR	NR	K	3-6:1	16	20
Toste et al. (2019)	RCT	RW	WR	NR	4, 5	3-4:1	40	40
Vadasy & Sanders (2011)	RCT	RW	LN; LS; PA	NR	1	1:1	108	30
Vadasy et al. (1997)	RCT	RW	LN, PA, Spell	ELL	1	1:1	100	30
Vadasy et al. (2006)	RCT	RW	V, RA, Spell	NR	1	1:1	100	30
Vadasy et al. (2000)	RCT	RW	LN, LS, PA, WR	NR	K	1:1	62	30
Vaughn et al. (2006)	RCT	RW	LS; WR	NR	1	3-5:1	120	50
Vernon-Feagans et al. (2018)	RCT	RW	LS; PA; WR	NR	K, 1	1:1	~16 to 36	15
Vernon-Feagans et al. (2012)	RCT	RW	R, NR	NR	K, 1	1:1	14	15
Vernon-Feagans et al. (2013)	RCT	RW	R, NR	NR	K, 1	1:1	~30 to 40	15

Note. BT IQ = below-typical IQ; ELL = English language learners/emergent bilinguals/multilingual leaners; HW = handwriting; ID = intellectual disability; K = Kindergarten; LN = letter names; LS = letter sounds; NR = not reported, or insufficient information available to calculate; PA = phonemic awareness; R = reading; RA = reading achievement; RC = reading comprehension; RCT = randomized control trial; RF = reading fluency; RW = reading/writing intervention; SCED = single case experimental design, multiple baseline; Spell = spelling; SWD = students with disabilities; W = writing; WA = writing achievement; WF = writing fluency; WR = word reading.

Table 2

Literature Review, Writing and Reading/Writing Intervention Components and Effects by Study

Study	Reading Skills Targeted	Writing Skills Targeted	Session Percent Writing	Outcomes	Effects
Alber-Morgan et al. (2016)	PA	Spell	NR	WR: RCM, Words Read Correctly	PLTC, 2/3 Students
Amendum et al. (2011)	LS, LN, PA, D, SWR (6 min); RF (9 min)	Spell (6 min, split with reading)	NR	WR: WJ-III Letter Word Identification WR: WJ-III Word Attack V: PPVT-III RC: WJ-III Passage Comprehension	0.47 0.46 0.09 0.42
Berninger et al. (1995)	LN	HW (5 min), Spell (15 min), TG P (5 min), SR (10 min)	100	WR: WRMT-R Word Attack WR: WRMT-R Word Reading	NS NS
Berninger et al. (1997)	None	HW (10 min)	100	LN: RCM, Letter Name Dictation	1.86
Berninger et al. (2002)	LN, LS, PA	Spell, TG P	NR	WR: WRMT-R Word Attack WR: WRMT-R Word Identification	0.18 0.12
Blachman et al. (2004)	LN, LS, D, RF	Spell, TG P (if time allowed)	NR	WR: WRMT-R Word Attack WR: WRMT-R Word Identification RF: GORT-3 Accuracy RF: GORT-3 Rate RC: GORT-3	0.84 0.75 0.58 0.70 0.51
Case et al. (2014)	LN, LS, PA, D (15 min, split with spelling), SWR (10 min),	HW, Spell (15 min, split with reading)	NR	WR: TOWRE Phonemic Decoding Fluency WR: WRMT-R Word Attack WR: WRMT-R Word Identification	0.15 0.23 0.21

Study	Reading Skills Targeted	Writing Skills Targeted	Session Percent Writing	Outcomes	Effects
	RF, V, RC (15 min)				
Englert et al. (1991)	RC	TG P, SR	NR	RC: RCM, Recall	Signif.
Fuchs et al. (2006)	None	Spell (10 min)	100	WR: WRMT-R Word Identification RC: CRAB Passage Reading Fluency	0.52 0.33
Georgiou et al. (2021)	LS, D	Spell	NR	WR: WRAT-4 Word Reading	0.28
Graham et al. (2002)	LN, LS, D	Spell	NR	WR: WRMT-R Word Attack WR: WRMT-R Word Identification	0.84 0.34
Hatcher et al. (1994)	LN, PA, D, RF	TG P	NR	WR: Early Word Recognition Test WR: BAS Word Reading WR: RCM, Nonword Reading Test RF: Neal Analysis of Reading Accuracy RC: Neal Analysis of Reading Comprehension	0.35 1.09 0.35 0.38 0.56
Hebert et al. (2018)	RC	TG P, SR	NR	RC: RCM, Oral Retell RC: RCM, Comprehension Test	-0.44 -0.56
Idol & Croll (1987)	RC	TG P	NR	RC: RCM, Comprehension Questions	PLC, 4/5 Students
Joseph (1999)	PA, D	Spell	NR	WR: RCM, Word Identification	PLTC, 3/3 Students
Joseph (2002)	LS, PA	Spell	NR	WR: RCM, Word Identification	PLTC, 3/3 Students
Keesey et al. (2015)	LS, PA	Spell	NR	PA: RCM, Auditory Segmenting PA: RCM, Nonsense Word Segmenting	PLTC, 3/3 Students PLTC. 3/3 Students
Lane et al. (2009)	D, V, RC (7-9 min); RF (8-9 min)	Spell, TG S (8-10 min)	36	PA: RCM, Phonological Awareness WR: RCM, Nonword Decoding WR: RCM, Sight Word Reading WR: WRMT Word Attack	0.70 0.70 0.69 1.28
Mason et al. (2013)	V, RC	TG P, SR	NR	RC: RCM, Oral Retell RC: TORC-3	0.59 0.55

Study	Reading Skills Targeted	Writing Skills Targeted	Session Percent Writing	Outcomes	Effects
Rashotte et al. (2001)[a]	PA (30 min); D, RC (15 min)	TG P (5-6 min)	10	PA: CTOPP Elision	0.40, 1.14
				PA: CTOPP Segmenting	1.41, 2.26
				PA: CTOPP Blending	1.08, 0.65
				WR: WRMT Letter Word	0.42, 0.57
				WR: WRMT Word Attack	1.67, 1.81
				WR: TOWRE Sight Word Efficiency	0.19, 0.22
				WR: TOWRE Decoding Efficiency	1.31, 1.91
				RF: GORT-3 Reading Rate	0.63, 0.23
				RF: GORT-3 Reading Accuracy	0.73, 1.15
				RC: WRMT Passage Comprehension	1.44, 0.86
				RC: GORT-3 Passage Comprehension	1.51, 0.60
Senechal et al. (2012)	LN, LS, PA, D	Spell	NR	LS: RCM, Letter Sounds	0.60
				PA: CTOPP	0.36
				WR: RCM, Sight Word Reading	0.27
Toste et al. (2019)	LS (3 min), D (11 min), RF	Spell (5-8 min)	NR	WR: WJ-III Word Attack	0.52
				WR: WJ-III Word Identification	0.45
				WR: TOWRE-2 Decoding Efficiency	0.09
				WR: TOWRE-2 Sight Word Efficiency	0.21
				WR: RCM, Multisyllabic Decoding	1.06
				RC: TOWRE-2 Passage Comprehension	-0.02
				RC: WRMT-4 Reading Comprehension	0.14
Vadasy et al. (1997)	LN, LS, PA, SWR	Spell, TG P	NR	PA: Yopp-Singer Segmentation	0.43
				WR: WJ-R Word Attack	0.22
				WR: Bryant Pseudoword	0.55
				WR: RCM, Pseudoword Reading	0.29
				WR: RCM, Sight Word Reading	0.15
				RF: Analytical Reading Inventory	0.16
				RA: WRAT-R	0.31

Study	Reading Skills Targeted	Writing Skills Targeted	Session Percent Writing	Outcomes	Effects
Vadasy et al. (2000)	LN, LS, PA, D, SWR, RF, V	Spell	NR	PA: Yopp-Singer Segmentation	0.85
				WR: WJ-R Word Attack	1.24
				WR: Bryant Pseudoword	1.08
				WR: RCM, Sight Word Reading	0.82
				RF: Analytical Reading Inventory	0.60, 0.42[b]
				RA: WRAT-R	0.91
Vadasy et al. (2006)	LS, PA, D, SWR, RF	Spell	NR	LN: DIBELS Letter Name Fluency	0.08
				PA: CTOPP	0.27
				WR: WRMT-R WA/WI	0.96
				WR: TOWRE	0.50
				RF: RCM, Passage Reading Fluency	0.83
				RC: WRMT-R Passage Comprehension	0.28
Vadasy & Sanders (2011)	LN, LS, PA, SWR, RF	Spell	NR	LS: RCM, Letter Names/Letter Sounds	0.82
				PA: CTOPP	-0.05
				WR: WRMT-R WA/WI	0.52
				RF: RCM, Passage Reading Fluency	0.69
				RC: WRMT-R Passage Comprehension	0.29
Vaughn et al. (2006)	LN, LS, PA, D, SWR, RF, V, RC	LSW	NR	LN: RCM, Letter Names	-0.23
				LS: RCM, Letter Sounds	-0.16
				PA: CTOPP	0.38
				WR: TOWRE	0.42
				WR: WJ-III Letter Word Identification	0.13
				WR: WJ-III Word Attack	0.42
				RF: DIBELS Oral Reading Fluency	0.12
				RC: WRMT-R Passage Comprehension	0.13
Vernon-Feagans et al. (2012)	PA, D, SWR, RF	Spell	NR	PA: CTOPP	NS
				WR: WJ-III Letter Word Identification	0.48
				WR: WJ-III Word Attack	NS
Vernon-Feagans et al. (2013)	LN, LS, PA, D, RF, V, RC	Spell	NR	WR: WJ-III Letter Word Identification	0.54
				WR: WJ-III Word Attack	0.36

Study	Reading Skills Targeted	Writing Skills Targeted	Session Percent Writing	Outcomes	Effects
Vernon-Feagans et al. (2018)	LN, LS, PA, D (6 min, split with spelling); RF (9); V, RC	Spell (6 min, split with reading)	NR	V: PPVT-III RC: WJ-III Passage Comprehension WR: WJ-III Letter Word Identification WR: WJ-III Word Attack RC: WJ-III Passage Comprehension	0.15 0.48 0.26 0.32 0.25

Note. BAS = British Ability Scales; CTOPP = Comprehensive Test of Phonological Processing; D = decoding; DIBELS = Dynamic Indicators of Basic Early Literacy Skills; GORT = Gray Oral Reading Test; LN = letter name knowledge; LS = letter sound knowledge; LSW = letter sound writing; NR = not reported; NS = not significant, as reported by author without sufficient data for effect size calculation; PA = phonemic awareness; PLTC = positive level and trend change in SCED graphed data; PLC = positive level change in SCED graphed data; PPVT = Peabody Picture Vocabulary Test; RC = reading comprehension; RCM = researcher/author-created measure; RF = reading fluency; Signif. = significant, as reported by author without sufficient data for effect size calculation; Spell = spelling; SR = self-regulation; SWR = sight word reading; TG P = text generation, passage; TOWRE = Test of Word Reading Efficiency; V = vocabulary; WA = Word Attack; WI = Word Identification; WJ-III = Woodcock Johnson Tests of Achievement, Third Edition; WR = word reading; WRAT = Wide Range Achievement Test; WRMT = Woodcock Reading Mastery Tests.

[a] Authors reported separate effect sizes for Grade 1-2, 3-4 students.

[b] Authors reported separate effect sizes for K, Grade 1 students.

Table 3

Teacher Demographics (N = 42)

Demographic	*n*	%
Gender		
Female	41	97.62
Male	1	2.38
Highest Degree Earned		
Bachelor's Degree	10	23.81
Doctorate in Education	1	2.38
Education Specialist	1	2.38
Master's Degree	7	16.67
Master's Plus Additional Coursework	23	54.76
Job Title		
ELL/ESL Teacher	5	11.9
Intervention Teacher	3	7.14
Literacy Specialist	3	7.14
Special Education Teacher	31	73.81
Race/Ethnicity		
Asian American/Pacific Islander	1	2.38
White	41	97.62
	M	*SD*
Years Teaching	12.8	8.61

Note. N reflective of teachers who completed the study. ELL = English Language Learner; ESL = English as a Second Language.

Table 4

Student Demographics (N = 105)

Demographic	Treatment (*n* = 49)		Control (*n* = 56)	
	n	%	*n*	%
Grade				
1	9	18.40	11	19.60
2	18	36.70	15	26.80
3	15	30.60	12	21.40
4	6	12.20	13	23.20
5	1	2.04	5	8.93
Gender[a]				
Female	16	32.70	17	30.40
Male	33	67.30	38	67.90
Race/Ethnicity[a]				
Asian	2	4.08	6	10.70
Black	12	24.50	11	19.60
Latino/a or Hispanic	6	12.20	7	12.50
Multi-Racial	2	4.08	5	8.93
White	27	55.10	26	46.40
Receiving English Language Learner Services[a]				
No	39	79.60	41	73.20
Yes	10	20.40	14	25.00
Receiving Free or Reduced Lunch				
No	21	42.90	18	32.10
Yes	17	34.69	17	30.40
Not reported	11	22.40	21	37.50
Primary Disability				
Autism	7	14.30	15	26.80
Developmental Delay	2	4.08	0	0.00
Emotional/Behavioral Disturbance	3	6.12	1	1.79
Intellectual Disability	3	6.12	2	3.57
Multiple Disabilities	0	0.00	1	1.79
None	14	28.57	17	30.36
Other Health Impairment	12	24.50	6	10.70
Specific Learning Disability	8	16.30	14	25.00
Speech/Language Disorder	1	2.04	0	0.00
Secondary Disability				
Autism	0	0.00	1	2.04
Intellectual Disability	0	0.00	1	2.04
None	23	41.07	14	28.57
Specific Learning Disability	0	0.00	2	4.08
Speech/Language Disorder	9	16.07	5	10.20
Not applicable	18	32.14	22	44.90

Demographic	Treatment (n = 49)		Control (n = 56)	
	n	%	*n*	%
Secondary Disability				
Not reported	6	10.71	4	8.16

Note. [a] Gender, race/ethnicity, and ELL services not reported for one control student.

Table 5

Data Collector CBM-R Administration Fidelity and Scoring Reliability (%)

Measure	Training			Screening			Posttest		
	N	*M*	Range	*N*	*M*	Range	*N*	*M*	Range
Administration									
LS	10[a]	96.2	93.0-100.0	8[b]	94.0	90.0-100.0	5[a]	96.7	91.7-100.0
DW	10[a]	100.0	100.0	8[b]	96.6	90.0-100.0	5[a]	98.3	91.7-100.0
Scoring									
LS CLSPM	10[c]	95.8	92.0-99.0	8[b]	95.9	92.5-100.0	8[c]	96.7	95-100.0
DW CWPM	10[c]	95.3	91.0-99.0	8[b]	96.0	90.9-100.0	8[c]	98.1	97-100.0

*Note. N*s reflective of the number of data collectors for each time point. CLSPM = correct letters sounded per minute; CWSPM = correct words per minute; DW = FastBridge Decodable Words; LS = FastBridge Letter Sounds.

[a] Mock administration format.

[b] Audio recording of student testing format.

[c] Computerized scoring practice format.

Table 6

Data Collector CBM-W Administration Fidelity and Scoring Reliability (%) at Training, Screening/Pretest, and Posttest

Measure	Training (N = 10)[a]		Screening/Pretest (N = 8)[b]		Posttest (N = 8)[b]	
	M	Range	*M*	Range	*M*	Range
Administration						
WD	99.0	92.0-100.0	98.0	93.0-100.0		
PW	99.0	96.0-100.0	98.5	91.0-100.0		
SP	100.0	98.0-100.0	99.0	94.0-100.0		
Scoring						
WD						
WW	100.0	100.0	100.0	100.0	98.8	93.0-100.0
WSC	98.7	96.0-100.0	97.3	86.2-100.0	99.4	97.3-100.0
C/ILS	98.4	94.1-100.0	97.7	94.3-100.0	98.7	97.3-100.0
PW						
WW	99.8	98.3-100.0	99.5	98.3-100.0	94.4	98.0-100.0
WSC	99.1	96.5-100.0	98.3	92.0-100.0	97.9	93.3-100.0
C/IWS	97.4	93.0-100.0	92.8	84.2-100.0	95.3	96.5-100.0
SP						
WW	99.8	98.0-100.0	100.0	100.0	98.6	96.1-100.0
WSC	98.5	92.0-100.0	97.9	93.3-100.0	93.3	84.9-100.0
C/IWS	92.2	83.8-98.5	93.5	87.8-100.0	91.4	84.1-100.0

Note. *N*s reflective of number of data collectors. Administration fidelity averaged across three measures and two administrations. Scoring reliability averaged across three scored samples. C/ILS = correct and incorrect letter sequences; C/IWS = correct and incorrect word sequences; PW = picture word; SP = story prompt; WD = word dictation; WSC = words spelled correctly; WW = words written.

[a] Mock administration format.

[b] Audio or video recording of student testing format.

Table 7

Number of Treatment Students Receiving Mini-Lessons, From Instructional Plans

Mini-Lessons	*n*	*%*
TR1: Phonics Warm-Up	35	72.9
TR2: Alphabet Practice	34	70.8
TR3: Word Building	46	95.8
TR4: Word Study	36	75.0
TR5: Alphabet Rockets	37	77.1
TR6: Word Sort	20	41.7
TR7: Sentence Completion	3	6.3
TG1.1-1.4: Sentence Construction	14	29.2
TG2: Sentence Combining	2	4.2
TG3: Repeated Writing	0	0.0
TG4: Writing Goals	0	0.0
TG5: Writing	3	6.3
Self-Regulation Strategies[a]	0	0.0

Note. Mini-lesson counts based on students' first writing instruction plans (N = 48) created by treatment teachers. TG = text generation; TR = transcription.

[a] Mini-lesson self-regulation strategies were incorporated into WIPs from Powerful Writing Strategies by Harris and Graham (2008).

Table 8

Percent of Students Receiving Intervention Targeting Writing Skills, From Teacher Survey

Writing Skill	Treatment (*n* = 35)		Control (*n* = 20)	
	n	*%*	*n*	*%*
Handwriting	30	85.7	11	55.0
Spelling	31	88.6	12	60.0
Mechanics	27	77.1	12	60.0
Grammar	10	28.6	11	55.0
Text Generation, Word Level	25	71.4	5	25.0
Text Generation, Sentence Level	14	40.0	11	55.0
Text Generation, Passage Level	3	8.6	8	40.0
Self-Regulation	21	60.0	5	25.0

Table 9

Percent of Students Receiving Intervention Targeting Reading Skills, From Teacher Survey

Reading Skill	Treatment (n = 30)		Control (n = 16)	
	n	*%*	*n*	*%*
Phonemic Awareness	28	93.3	15	93.8
Decoding	30	100.0	12	75.0
High-Frequency Word Reading	26	86.7	12	75.0
Reading Fluency	22	73.3	9	56.3
Vocabulary	13	43.3	12	75.0
Reading Comprehension	24	80.0	11	68.8

Note. Activities occurred during students' reading intervention time. Five treatment and four control students did not receive reading intervention and are not included.

Table 10

Percent of Students Experiencing Reading Risk Before Intervention

Reading Risk	LS CLSPM		DW CWPM	
	n	*%*	*n*	*%*
Grade 1				
None	20	100.0	9	45.0
Some	0	0.0	11	55.6
High	0	0.0	0	0.0
Grade 2				
None	9	27.3	18	54.5
Some	8	24.2	3	9.1
High	16	48.8	12	36.4
Grade 3				
None	5	18.5	15	55.6
Some	14	51.9	4	14.8
High	8	29.6	8	29.6
Grade 4				
None	5	26.3	15	79.0
Some	7	36.8	1	5.3
High	7	36.8	3	15.8
Grade 5				
None	0	0	6	100.0
Some	4	66.7	0	0.0
High	2	33.3	0	0.0
Total				
None	39	37.1	63	60.0
Some	33	31.4	19	18.1
High	33	31.4	23	21.9

Note. Reading risk based on Fall, Grade 1 FastBridge Benchmarks for first grade participants, and Spring, Grade 1 FastBridge Benchmarks for second through fifth grade participants.

Table 11

Correlations Between CBM-R and Writing Measures and Scoring Procedures for Lower and Upper Elementary Grades

	Measure	1	2	3	4	5	6	7	8	9	10	11	12	13
1	LS CLS.	-	.46***	.55***	.33**	.38**	.63***	.61***	.36**	.59***	.51***	-.26	.32*	.59***
2	DW CW.	.34*	-	.62***	.77***	.79***	.46***	.50***	.41**	.53***	.59***	.13	.67***	.56***
3	WD WW	.69***	.56***	-	.76***	.67***	.79***	.74***	.26	.72***	.64***	-.13	.51***	.64***
4	WD WSC	.64***	.74***	.74***	-	.92***	.68***	.70***	.48***	.51***	.58***	.27	.73***	.63***
5	WD CILS	.72***	.68***	.66***	.91***	-	.60***	.65***	.57***	.55***	.67***	.30*	.79***	.71***
6	PW WW	.64***	.59***	.81***	.69***	.64***	-	.96***	.32*	.68***	.57***	-.21	.43**	.59***
7	PW WSC	.58***	.66***	.72***	.71***	.67***	.93***	-	.45***	.65***	.60***	-.07	.52***	.61***
8	PW CIWS	.27*	.51***	.21	.46***	.47***	.25	.42**	-	.22	.38**	.33*	.57***	.49***
9	SP WW	.54***	.63***	.75***	.70***	.67***	.69***	.64***	.20	-	.89***	-.30*	.41**	.64***
10	SP WSC	.46***	.71***	.65***	.78***	.69***	.64***	.66***	.32*	.90***	-	.09	.63***	.67***
11	SP CIWS	-.39**	-.10	-.43**	-.100	-.24	-.29*	-.16	.07	-.54***	-.18	-	.48***	.14
12	KTEA Sp.	.57***	.64***	.57***	.65***	.69***	.59***	.57***	.39**	.61***	.58***	-.27	-	.70***
13	KTEA W.	.56***	.51***	.62***	.59***	.61***	.57***	.49***	.30*	.67***	.60***	-.34*	.87***	-

Note. CILS = correct minus incorrect letter sequences; CIWS = correct minus incorrect word sequences; DW CW. = Decodable Words, correct words per minute; KTEA Sp. = Kauffman Test of Educational Achievement, Third Edition, Spelling scale; KTEA W. = Kauffman Test of Educational Achievement, Third Edition, Written Expression scale; LS CLS. = Letter Sounds, correct letter sounds per minute; PW = Picture Word; SP = Story Prompt; Word Dictation = Word Dictation; WSC = words spelled correctly;

WW= words written. Correlations for Grades 1-2 (n = 53) reported in the lower portion of table, and correlations for Grades 3-5 (n = 52) are reported in the upper portion. *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

Table 12

Descriptive Statistics for Outcome Measures

Measure	Treatment					Control				
		Pretest		Posttest			Pretest		Posttest	
	n	*M*	*SD*	*M*	*SD*	*n*	*M*	*SD*	*M*	*SD*
LS CLSPM										
Grade 1	9	20.33	11.84	38.11	18.67	11	22.09	13.96	36.27	2.79
Grade 2	18	31.67	17.28	41.44	2.18	15	25.53	17.38	36.6	21.19
Grade 3	15	30.20	17.91	40.40	14.96	12	28.17	12.72	31.25	14.58
Grade 4-5[a]	7	21.57	7.68	28.00	12.07	18	33.67	13.37	37.00	14.78
Total	49	27.69	15.92	38.59	17.5	56	28.04	14.80	35.52	17.55
DW CWPM										
Grade 1	9	2.22	2.68	11.00	11.81	11	2.55	3.36	11.00	12.64
Grade 2	18	14.44	15.43	29.79	26.59	15	24.24	26.31	30.87	26.20
Grade 3	15	20.93	2.42	33.80	3.97	12	21.70	2.22	28.00	23.12
Grade 4-5[a]	7	18.79	15.83	27.91	25.92	18	30.75	2.09	38.01	25.72
Total	49	14.80	16.80	27.30	26.51	56	21.53	22.06	28.65	24.65

Note. Only students who completed posttesting (N = 105) are included in these pre- and posttest descriptive statistics. DW CWPM = Decodable Words correct words per minute; LS CLSPM = Letter Sounds correct letter sounds per minute.

[a] Grade 4 and 5 collapsed due to n = 1 Grade 5 treatment student. Grade was not collapsed for models reported in Tables 13 and 14.

Table 13

Taxonomy of Models Predicting Posttest LS CLSPM Score Including Fixed Effects Coefficients (Standard Errors)

Coefficient	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	28.89 (2.691)***	15.14 (2.704)***	21.88 (3.527)***	20.39 (3.820)***	19.57 (4.247)***
Pre LS CLSPM		0.78 (0.084)***	0.82 (0.081)***	0.82 (0.080)***	0.85 (0.115)
Grade			-2.99 (1.073)**	-2.85 (1.080)**	-2.92 (1.087)**
Condition	-1.54 (3.983)			2.46 (2.493)	4.41 (5.072)
Pre LS x Condition					-0.07 (0.161)
ICC teacher	0.36	0.11	0.05	0.04	0.04
AICc	897.60	839.46	834.54	835.82	837.93
Delta AICc	63.06	4.92	0.00	1.29	3.39
χ^2	-	-	7.13**	0.96	0.19
Log Likelihood	-444.60	-415.53	-411.97	-411.48	-411.39

Note. Models fitted to predict LS CLSPM slope for 105 students in 42 teacher clusters. All models included random effects of teacher intercept and were fitted using maximum likelihood. ICC = intra-level correlation coefficient; AICc = corrected Akaike Information Criterion; BIC = Bayesian Information Criterion; Pre LS CLSPM = student pretest Letter Sound correct letter sounds per minute score. Delta AICc calculated based on model 3. χ^2 not calculated for Models 1 and 2, as models do not contain nested, sequentially more complex predictors. *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

Table 14

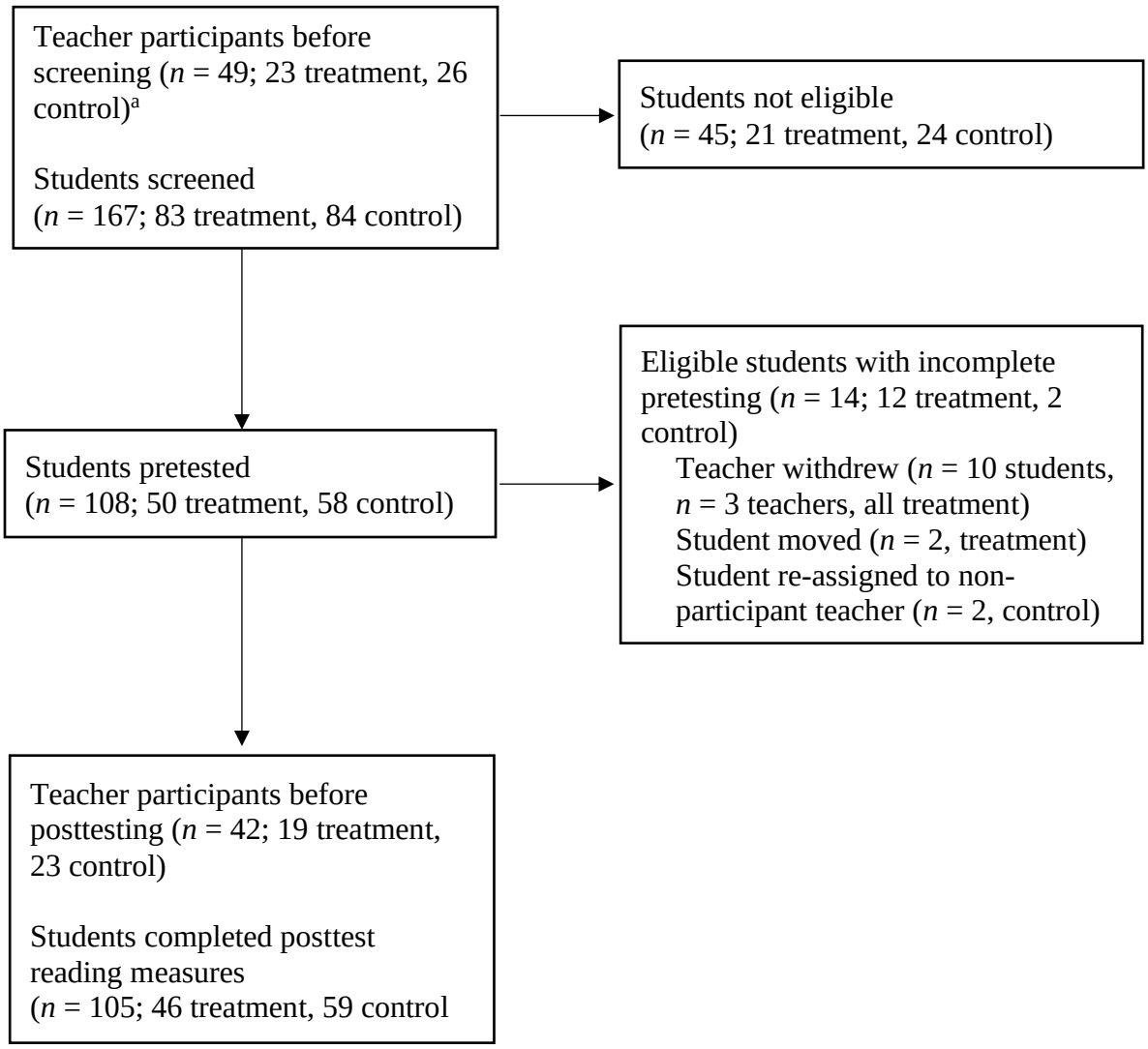
Taxonomy of Models Predicting Log-Transformed Posttest DW CWPM Score Including Fixed Effects Coefficients (Standard Errors)

Coefficient	Model 1	Model 2	Model 3	Model 4
Intercept	2.82 (0.228)***	1.16 (0.102)***	1.02 (0.116)***	1.02 (0.139)***
Log Pre DW CWPM		0.76 (0.040)***	0.77 (0.038)***	0.77 (0.050)***
Condition	-0.12 (0.338)		0.23 (0.111)*	0.23 (0.196)
Log Pre DW x Condition				0.00 (0.076)
ICC teacher	0.54	0.09	0.03	0.03
AICc	330.24	185.71	183.98	186.23
Delta AICc	146.26	1.73	0.00	2.25
χ^2	-	-	3.94*	0.00
Log Likelihood	-160.92	-88.66	-86.69	-86.69

Note. Models fitted to predict DW CWPM slope for 105 students in 42 teacher clusters. All models included random effects of teacher intercept and were fitted using maximum likelihood. ICC = intra-level correlation coefficient; AICc = corrected Akaike Information Criterion; Pre DW CWPM = student pretest Decodable Words correct letter sounds per minute score. Delta AICc calculated based on model 3. χ^2 not calculated for Models 1 and 2, as models do not contain nested, sequentially more complex predictors. *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

Figure 1

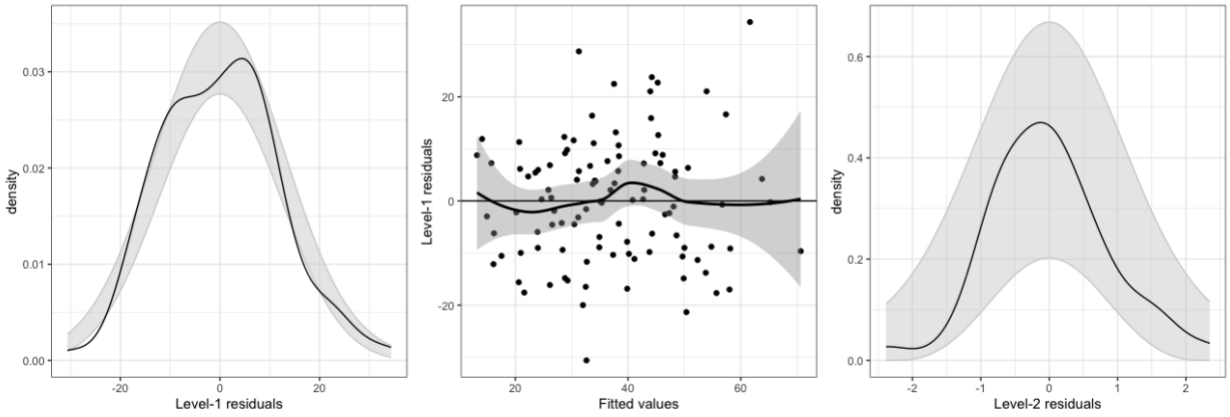
Consort Diagram of Teacher and Student Participants at Each Testing Timepoint



Note. [a] Three control teachers dropped before nominating students for screening.

Figure 2

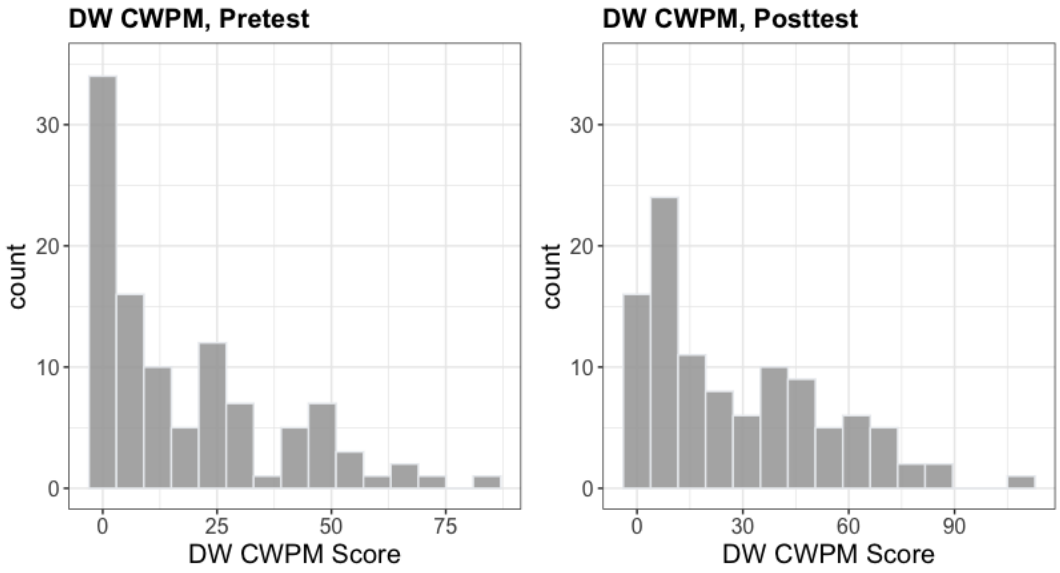
LS CLSPM Model of Best Fit, Density Plots of Level 1 and 2 Residuals and Scatterplot of Fitted Values vs. Level 1 Residuals



Note. Scatterplot fitted using residuals from LS CLSPM Model 3. In density plots, the bootstrapped confidence envelope (in grey) shows the sampling variation in density expected under the normality assumption. In the scatterplot of the residuals, a horizontal line at $Y = 0$ shows the expected mean residual. The loess line (black) and uncertainty bands (grey) are also displayed. Density plots of level 1 and 2 residuals indicate that the normality assumption is tenable. The scatterplot of the fitted values versus level 1 residuals indicates that the homoscedasticity assumption is tenable.

Figure 3

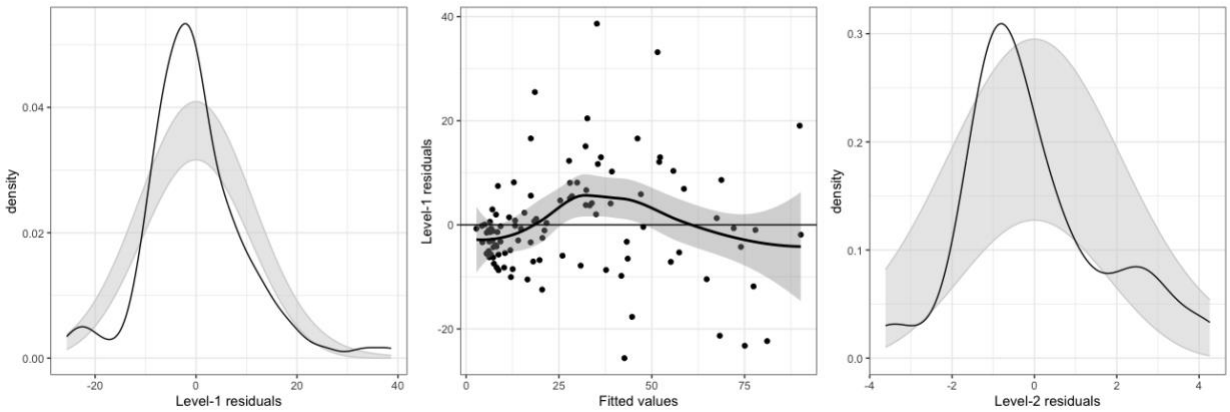
Distributions of Non-Transformed DW CWPM Scores at Pre- and Posttest



Note. The appearance of a possible bimodal distribution at posttest is driven by clustering of grade level scores.

Figure 4

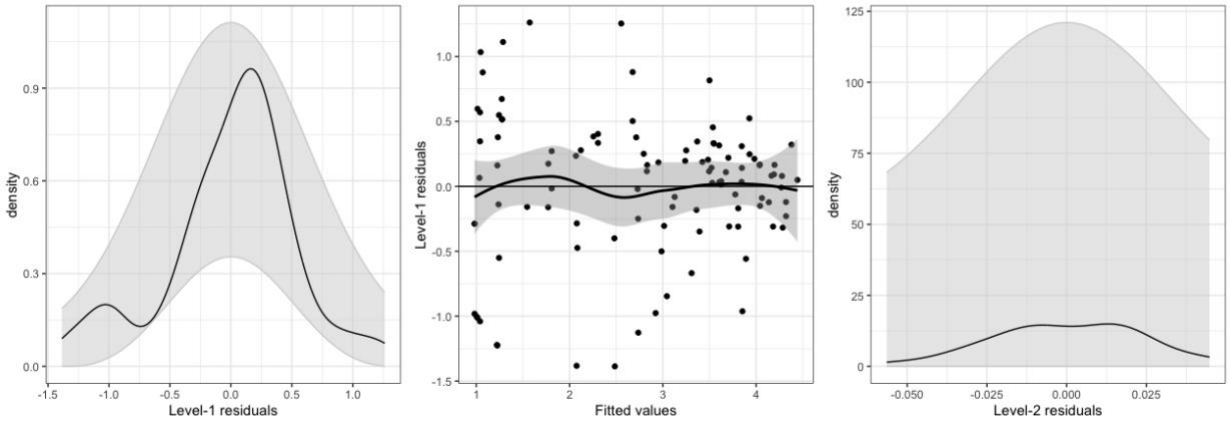
Non-Transformed DW CWPM Model of Best Fit, Density Plots of Level 1 and 2 Residuals and Scatterplot of Fitted Values vs. Residuals



Note. Density plots and scatterplot fitted using residuals from a best-fitting DW CWPM model using non-transformed pre- and posttest scores. In density plots, the bootstrapped confidence envelope (in grey) shows the sampling variation in density expected under the normality assumption. In the scatterplot of the residuals, a horizontal line at $Y = 0$ shows the expected mean residual. The loess line (black) and uncertainty bands (grey) are also displayed. Level 1 residual density plot indicates normality assumption may be violated. Level 1 fitted values suggest that the homoscedasticity assumption may be tenable.

Figure 5

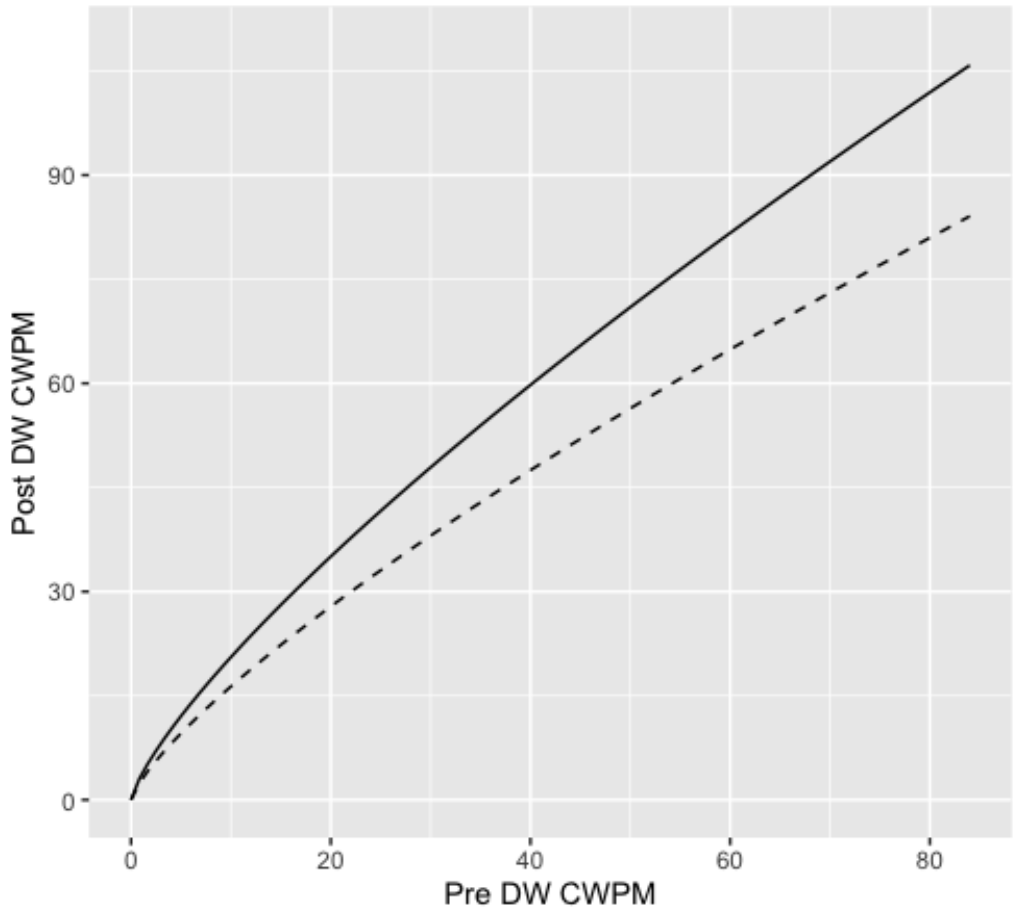
Log-Transformed DW CWPM Model of Best Fit, Density Plots of Level 1 Residuals and Scatterplot of Fitted Values vs. Level 1 Residuals



Note. Density plots and scatterplot fitted using residuals from DW CWPM Model 3 using log-transformed pre- and posttest scores. In density plots, the bootstrapped confidence envelope (in grey) shows the sampling variation in density expected under the normality assumption. In the scatterplot of the residuals, a horizontal line at $Y = 0$ shows the expected mean residual. The loess line (black) and uncertainty bands (grey) are also displayed. Level 1 residual density plot indicates normality assumption is tenable. Level 1 fitted values suggest that the homoscedasticity assumption may be tenable.

Figure 6

Plot of Predicted Posttest DW CWPM Scores as a Function of Pretest Scores and Experimental Condition



Note. Fitted regression lines are displayed for treatment (solid line) and control (dashed line) students.

Appendix A

LS and DW Additional Administration Procedures

Before beginning LS, students are given a practice sheet of three letters and asked to name the sounds; if the student makes a mistake, the test administrator provides the correct sound. For both subtests, after reading aloud the directions and asking the student to begin, the test administrator starts the timer and follows along with students' responses on a separate scoring sheet, marking incorrect responses.

Incorrect responses in the LS assessment include pausing for more than three seconds (at which point the administrator supplies the letter sound/word and points to the next letter/word), skipping a letter/word, or mispronouncing a letter sound/word. In DW, students are not penalized for saying the sounds of the word and then the word. In both LS and DW, students are not penalized for self-correction or pronouncing letter sounds/words differently due to speech or dialectical differences. At the end of one minute, the test administrator marks the final letter/word a student read.

Appendix B

CBM Administration and Scoring Procedures

CBM-W Administration and Scoring

CBM-W Administration and Scoring Training. To collect CBM-W data, data collectors received training from primary investigators (PIs) and project coordinators (PCs). Cross-site reliability of CBM-W scoring and CBM administration fidelity scoring was established before training among the PCs at the two sites, with PCs meeting criteria of 85% and 95% agreement, respectively. Training was conducted in the summer of 2021, before student data collection began. Data collectors viewed a two-hour presentation that provided an overview of CBM-W measures, their purposes, and scoring and administration procedures. Data collectors were also given access to researcher-created scoring guides and administration directions for each measure.

CBM-W Administration and Scoring Evaluation. As part of training, data collectors practiced CBM-W administration with a partner. After training, data collectors performed a mock administration of each CBM-W. Average post-training CBM administration fidelity, across CBM-W measures, ranged from 99 to 100%. After training, data collectors independently scored two samples of each CBM-W measure (Word Dictation, Picture Word, and Story Prompt). PCs then checked their scored samples for inter-scorer agreement. PCs met with each data collector to review inter-scorer agreement results and provide feedback on any scoring discrepancies. This process was then repeated with a second set of sample CBM-Ws. If GRAs did not obtain 85% or higher inter-scorer agreement, they completed a third set of sample CBM-Ws. Average CBM-W scoring reliability, across measures, scoring procedures, and samples, ranged from 91.1% to 100%. All but one GRA met scoring reliability criteria after two rounds of CBM samples; this GRA met criteria after the third set of CBM samples. PCs evaluated data collector scoring reliability again during student screening, pre- and post-testing. At each time point, data collectors provided 10% of their scored student CBMs for PC inter-scorer agreement. If the 85% agreement criterion was not met on a measure, the GRAs provided additional samples for that measure.

CBM-R Administration and Scoring

CBM-R Administration and Scoring Training. The author, a GRA with four years of experience administering and scoring early CBM-R measures as a special education teacher, trained the data collection team in CBM-R administering and scoring procedures. Training was conducted in the summer of 2021, before the beginning of Early Writing Project pretesting.

Administration training included asynchronous videos directing data collectors through each measure's written FastBridge administration guide (8 and 5 min for LS and DW, respectively). Data collectors then practiced reading administration directions aloud, either independently or with a partner. Administration fidelity was measured using FastBridge's Observing and Rating Administrator Accuracy Form. This form included a checklist of administration steps for both LS and DW, which were identical with the exception of one additional item for LS for the practice session before administration. Checklist steps were scored as 1 for "completed accurately" and 0 for "completed inaccurately". Fidelity was calculated as a percent of steps completed accurately divided by total possible steps for both LS and DW.

Scoring training consisted of videos reviewing each measure's scoring directions as outlined in the FastBridge administration guide (8 and 5 min for LS and DW, respectively). Then, data collectors watched additional training videos modeling LS and DW scoring using

practice sessions from FastBridge's training website (8 and 2 min, respectively). These online training sessions included an audio recording of a student reading from a LS or DW probe, a timer, and an administrator copy of a probe on which the administrator could mark incorrect answers. After modeling scoring, the trainer explained why incorrect responses were marked as incorrect.

CBM-R Administration and Scoring Evaluation. Fidelity of CBM-R administration was evaluated after training by the GRA who conducted training. PCs also conducted fidelity evaluations after reviewing training materials. In late August and early September 2021 (before screening), the PC or GRA observed data collector's mock LS and DW administration. Data collectors needed a fidelity score of 90% or above to begin screening student participants; all data collectors met this criterion for both measures (LS *M*=96.2%, range = 93.0 to 10.0%; DW *M* = 100%).

As part of scoring training, data collectors independently practiced LS and DW scoring by completing three of FastBridge's training sessions for each measure. The training sessions allowed GRAs to view discrepancies in scoring. Data collectors also received a reliability score from the website (percentage agreement) and redid practice sessions in which they received scores of less than 90%.

Before screening, data collectors completed scoring checkouts using two "certification" practice sessions from the FastBridge website for each measure. Data collectors were required to meet 90% agreement in each certification session. Ten of the eleven data collectors met this criterion. One GRA scored 89% on one LS certification session. After receiving feedback, this GRA completed an additional certification session, bringing her average LS reliability to 92.0%. Average reliability on certification sessions was 95.8% for LS (range=92.0 to 99.0%) and 95.3% for DW (range=91.0 to 99.0%).

The PCs of MO and a GRA from MN evaluated data collectors' CBM-R administration fidelity and scoring reliability during student testing. Administration fidelity was evaluated via audio recordings of LS and DW administration for two students. Two data collectors did not complete this round of fidelity, due to the fact that they did not screen students. The data collectors who screened students were required to meet an average fidelity score of 90% or above. Seven of the eight data collectors met this criterion; one data collector received an average DW fidelity score of 88.9%. After receiving feedback, this data collector recorded an additional student administration, bringing her average DW fidelity score above 90%.

CBM-R administration fidelity was evaluated again before student posttesting, in February 2022, via mock observation of both LS and DW administration. The data collectors employed by the University of Minnesota did not conduct posttesting, and thus the fidelity of the remaining eight GRAs was evaluated. Additionally, MO posttest admin fidelity was not recorded; thus, the admin fidelity of n = 5 GRAs is available. Average posttest LS fidelity was 96.7% (range = 91.7 to 100%). Average DW fidelity was 98.3% (range = 91.7 to 100%).

Data collectors' reliability of LS and DW scoring was evaluated again during pretesting (late September to early October 2021). Data collectors recorded audio of their first two LS and DW pretest sessions with students. The GRA or PCs who trained them in CBM-R data collection then listened to the students' responses and scored separately. The training GRA and PCs then calculated reliability of CBM-R scoring using point-by-point agreement. Data collectors' final reliability score for each measure was calculated as an average of the two students' reliability

scores. Average pretest reliability was 95.9% (range = 92.5 to 100%) for LS and 96.0% (range = 9.9 to 100%) for DW.

Reliability of LS and DW scoring was evaluated again before posttesting (late February to early March 2022). Data collectors completed scoring checkouts using the same certification practice sessions from the FastBridge website and were required to meet 90% agreement for each certification session. Average posttest reliability was 96.7% (range = 95.0 to 100%) for LS and 98.1% (range = 97.0 to 100%) for DW.

Appendix C

CBM-W (Word Dictation, Picture Word, Story Prompt) Administration Fidelity Measures Fidelity Tool
CBM-W: Word Dictation

Implementer:	Start time:
Observer/rater:	End time:
Date:	Fidelity rating: # Yes ÷ # Yes + No = %

Part I. Administering the Assessment. Observe the assessment implementation, complete the checklist to the extent that the components were administered, and write detailed notes regarding other components observed.

Bolded items must always be scored ('1' or '0') for every administration, including shortened directions.

	Yes 1	No 0	N/A	Observation notes:
Has materials on hand				
a. **Timer**				
b. **Pencils**				
c. **Directions for administration**				
d. **Teacher copy of the task**				
e. **Student copy of Word Dictation Task**				
Follows the directions in order				
a. **Places student copy in front of student**				
b. **Tells student he/she will be writing words**				
c. Explains what to do if student does not know how to spell a word				
d. **Reminds student to do his/her best work**				
e. Practices a sample word				
f. Explains how the student should proceed through task				
g. Tells student what to do if they make a mistake				
h. Asks the student if they have any questions				

i. Reminds student to do their best				
j. Says "Here is your first word."				
k. **Does not add extra verbal directions, such as "The next word is…"**				
l. **When timer rings, says, "Stop, thank you for working so hard!"**				
During administration				
a. **Clearly says each word two times**				
b. If student pauses for more than 5 seconds, prompts student to try the next word				
c. If the student finishes before 3 minutes, teacher records remaining time on the student form				
Overall evaluation				
a. **Administrator follows directions in order**				
b. **Administrator starts/stops timer at the correct times**				
c. **Administrator maintains student attention and on-task behavior**				

Fidelity Tool
CBM-W: Picture Word Prompt

Implementer:	Start time:
Observer/rater:	End time:
Date:	fid_cbm = CBM fidelity = # Yes ÷ # Yes + No = _____%

Part I. Administering the Assessment. Observe the assessment implementation, complete the checklist to the extent that the components were administered, and write detailed notes regarding other components observed.

Bolded items must always be scored ('1' or '0') for every administration, including shortened directions.

	Yes 1	No 0	N/A	Observation notes:
1. *Has materials on hand*				
a. **Timer**				
b. **Pencils**				
c. **Directions for administration**				
d. Teacher copy of the task				
e. **Picture Word task for students**				
2. *Follows the directions in order*				
a. **Places prompt and pencil in front of each student**				
b. **Tells students they will be writing sentences**				
c. Presents model with 'Car' in a sentence, prompts student to begin with capital and end with punctuation				
d. **Instructs student to write one sentence for each picture**				
e. **Demonstrates how to start at top of page and go to next page until end for each picture**				
f. Reminds students to keep writing and go back and add detail and/or check sentences if they finish before time				
g. **Tells student what to do when time is up.**				
h. Tells student what to do if they don't know how to spell a word				
i. **Reads each word while students point**				
j. Reminds students they have 3 min and to focus on writing their best sentences, not writing fast				
k. Asks if students have questions and pauses				
l. Tells students how to begin and to do their best writing				
m. **Stops student(s) at 3 minutes.**				

For group admin, asks students to raise hand with pencil				
During administration				
a. Prompts to keep writing or go back and check work if student pauses more than 10 seconds or finishes before 3 minutes				
b. If student continues writing after timer, indicates/marks where student was at 3 minutes				
Overall evaluation				
a. **Administrator followed directions in order**				
b. **Administrator starts/stops timer at the correct times**				
c. **Administrator maintains student attention and on-task behavior**				

Fidelity Tool
CBM-W: Story Prompt

Implementer:	Start time:
Observer/rater:	End time:
Date:	CBM Fidelity Rating (fid_cbm): ____ # Yes ÷ ___(# Yes + # No) = ____%

Part I. Administering the Assessment. Observe the assessment implementation, complete the checklist to the extent that the components were administered, and write detailed notes regarding other components observed.

Bolded items must always be scored ('1' or '0') for every administration, including shortened directions. "NA" can be used for non-bolded items when administering shortened directions.

	Yes 1	No 0	NA	Observation notes:
Has materials on hand				
a. **Timer**				
b. **Pencils**				
c. **Directions for administration**				
d. Story starter prompt displayed for student(s) (for group admin)				

e. **Story Prompt task for student(s)**				
Administration Directions				
a. **Tells student(s) that they will be writing a story**				
b. **Tells students they will be provided with a story starter as an idea for their story**				
c. **Tells student(s) that they will think and then write**				
d. **Tells student(s) they need to use the story starter**				
e. **Tells student(s) to do their best work**				
f. Tells student(s) what to do if they don't know how to spell a word				
g. Tells student(s) what to do if they make a mistake				
h. Asks if student(s) has questions and pauses				
i. **Passes out student copy**				
j. **Tells student(s) to keep pencils down and examiner reads story starter**				
k. **Gives 30 seconds of think time**				
l. **Tells student(s) they have 3 minutes to write**				
m. **Tells students to keep writing until the timer rings.**				
n. Tells students to write their best story and keep writing the entire time				
o. Tells student(s) to raise hand with pencil when timer rings				
p. **Prompts student(s) to begin**				
q. **Stops student(s) at 3 minutes.** For group admin, asks students to raise hand with pencil				
During Administration				
a. Prompts to keep writing if the student puts his/her pencil down or go back and check work if student pauses more than 10 seconds or finishes before 3 minutes				
b. If a student continues writing after timer, indicates/marks where student was at 3 minutes				
Overall Evaluation				

a. **Administrator followed directions in order**				
b. **Administrator starts/stops timer at the correct times**				
c. **Administrator maintains student attention and on-task behavior**				

Appendix D

FastBridge CBM-R Administration Fidelity Measure

earlyReading One-Minute Measures

OBSERVING & RATING ADMINISTRATOR ACCURACY (ORAA)

This tool is used for training and coaching to standardized administration of Letter Names, Letter Sounds, Nonsense Words, Decodable Words, Sight Words, and Sentence Reading earlyReading assessments for FastBridge. The observer indicates if the procedure was completed accurately and not. If the step was not applicable for this administration, write N/A.

Examiner: _____ **Site:** _____

Observer: _____

Observation Period: O **Fall** O **Winter** O **Spring**

1 = Completed Accurately **0** = Completed Inaccurately

Testing Procedure	Letter Names	Letter Sounds	Nonsense Words	Decodable Words	Sight Words	Sentence Reading
Date Observed						
Places practice page in front of student						
Places copy of passage in front of student.						
Places examiner materials out of view of student.						
Seated appropriate distance from student.						
Follows standardized directions						
Says **READY? BEGIN**						
Starts timer immediately when child says the first word or letter						
Examiner follows along as student provides answers aloud, marking errors as they occur						
Provides appropriate 3-second rule responses when needed.						
Does NOT provide any other guidance to student during the test.						
Says "STOP" at end of 1 minute and stops timer.						
Marks last letter, sound, or word.						
Calculates score if paper/pencil administration						
Total score	/13	/13	/13	/12	/13	/12

Optional Score Verification	Letter Names	Letter Sounds	Nonsense Words	Decodable Words	Sight Words	Sentence Reading
Student score as recorded by examiner						
Student score as recorded by observer						
Percent Agreement*						

*Percent Agreement Formula:

# of Items Agreed Upon
Total # of Items Completed

Note. Only Letter Sounds (third column) and Decodable Words (fifth column) administration procedures were evaluated.

Appendix E

The Early Writing Project Mini-Lesson Titles and Objectives

Mini-Lesson Title	Student Objective
TR1: Phonics Warm-Up	Correctly identify letter(s) corresponding to sounds for short vowels, consonants, blends, and digraphs.
TR2: Alphabet Practice	Correctly and efficiently write the letters of the alphabet.
TR3: Word Building	Practice writing words from basic word stems to improve spelling.
TR4: Word Study	Study and practice writing words for mastery to improve spelling.
TR5: Alphabet Rockets	Improve handwriting skills on target letters learned in the alphabet practice activity.
TR6: Word Sort	Practice identifying and discriminating between pairs of word sounds or endings.
TR7: Sentence Completion	Incorporate words from the word sort to complete sentences.
TG1.1: Sentence Construction	Use capitalization and end punctuation to write complete, grammatically and syntactically correct sentences.
TG1.2: Sentence Construction	Use subjects and verbs to write complete, grammatically and syntactically correct sentences.
TG1.3: Sentence Construction	Improve sentence coherence.
TG1.4: Sentence Construction	Expand sentences by adding adjectives and adverbs.
TG2: Sentence Combining	Use grammatical strategies to combine simple and compound sentences.
TG3: Repeated Writing	Increase handwriting automaticity (rate of production in handwriting) through repeated practice.
TG4: Writing Goals	Increase handwriting automaticity (rate of production in handwriting) through performance-based incentives.
TG5: Writing	Write a narrative or informational story using all target letters and words learned so far.

Note. TG = text generation; TR = transcription.

Appendix F

Teachers' Reading and Writing Intervention Survey
The Early Writing Project Post Survey 21-22

Start of Block: Introduction

Thank you for participating in The Early Writing Project!

Your responses to the following survey are very important, because they will help us evaluate the effects of our professional development system on the knowledge, skills, and beliefs of teachers like you. Please take your time and answer each question as best you can. If you are not sure of an answer, that's OK! We just ask that you do your best.

You might wish to have a scratch piece of paper on hand to work out some of your answers.

If you need to change any of your responses within a block of questions, you will be able to navigate back to a question you previously answered by using the back button in the bottom left part of your screen.

If at any time you need to stop taking the survey, you can return to where you left off by clicking on the link that was emailed to you.

End of Block: Introduction

Start of Block: Teacher ID

Q1 Please enter the four-digit Early Writing Project study ID number that was emailed to you. If you did not receive a number, please contact Erica Lembke (Missouri) at lembkee@missouri.edu or Kristen McMaster (Minnesota) at mcmas004@umn.edu before proceeding.

_____

Q95 Were you part of the treatment or control group in the 2021-2022 cohort?

- ○ Treatment (1)
- ○ Control (2)

End of Block: Teacher ID

[Teachers complete survey subsections – DBI Knowledge and Skills, Writing Instruction Self-Efficacy, Writing Orientation, Program Feedback, and Implementation]

Start of Block: Reading and Writing Intervention

Q133 In this optional section of the survey, we're interested in learning more about whether, and how, teachers connect intensive **reading and writing** instruction.

This section will take about **10-15 minutes** to complete. If you choose to complete the survey, we would like to give you a **$10 Tango gift card** to thank you for your time. Would you like to proceed with this section?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Block If In this optional section of the survey, we're interested in learning more about whether, and how,... = No

Q134 Thank you for participating! Please enter your preferred email address below for us to send you your $10 gift card.

_____

Q135 Do all of your target students receive both reading and writing interventions in the same instructional groups?

Example: Sally and Sam, my two Early Writing Project target students, both receive writing intervention from 11:30-12 on Tuesdays and Thursdays. They also receive reading intervention together 9-9:30 on MWF.

- ○ Yes, my target students are in the same reading and writing intervention groups. (1)
- ○ No, my target students are not in the same reading and writing intervention groups. (2)

End of Block: Reading and Writing Intervention

Start of Block: Reading and Writing Intervention - All Target Students

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = Yes, my target students are in the same reading and writing intervention groups.

Q136 How are reading and writing interventions provided to your target students?

Please select a choice based on interventions, delivered in a small group/one-on-one format, as designated by a students' IEP services or RTI/MTSS tier.

- ○ They get writing intervention only. (1)
- ○ They get both reading and writing intervention time, delivered separately. (2)
- ○ They get a combined reading and writing intervention time. (3)

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get both reading and writing intervention time, delivered separately.

Q137 How many days per week do they receive *reading* intervention, on average?

0 1 2 3 4 5

Days ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get both reading and writing intervention time, delivered separately

Q138 How many minutes is **each** reading intervention session, on average?

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get writing intervention only.

Or How are reading and writing interventions provided to your target students? Please select a choic... = They get both reading and writing intervention time, delivered separately.

Q139 How many days per week do they receive *writing* intervention, on average?

0 1 2 3 4 5

Days ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get writing intervention only.

Or How are reading and writing interventions provided to your target students? Please select a choic... = They get both reading and writing intervention time, delivered separately.

Q140 How many minutes is **each** writing intervention session, on average?

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get a combined reading and writing intervention time.

Q141 How many days/week do they receive reading/writing intervention, on average?

0 1 2 3 4 5

Days ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get a combined reading and writing intervention time.

Q142 How many minutes is **each** reading/writing intervention session, on average?

0 5 10152025303540455055606570758085 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get a combined reading and writing intervention time.

Q143 How many minutes of **each** reading/writing intervention session are spent on *reading* skills, on average?

0 5 10152025303540455055606570758085 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get a combined reading and writing intervention time.

Q144 How many minutes of **each** reading/writing intervention session are spent on writing skills, on average?

0 5 10152025303540455055606570758085 90

Minutes ()	

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = Yes, my target students are in the same reading and writing intervention groups.

Q145 Which reading skills are targeted in their reading and/or writing intervention? Check all that apply.

- ☐ Phonological/phonemic awareness (1)
- ☐ Decoding (2)
- ☐ Sight word reading (3)
- ☐ Reading fluency (4)
- ☐ Vocabulary (5)
- ☐ Reading comprehension (6)
- ☐ No reading skills are targeted (7)

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = Yes, my target students are in the same reading and writing intervention groups.

Q146 Which skills are targeted in this student's reading and/or writing intervention? Check all that apply.

Please note: text generation = turning ideas into text; self-regulation = what writers do to meet their writing goals (e.g., planning, organizing, revising).

- ☐ Handwriting (1)
- ☐ Spelling (2)
- ☐ Mechanics (3)
- ☐ Grammar/syntax (4)
- ☐ Text generation, word level (5)
- ☐ Text generation, sentence level (6)
- ☐ Text generation, passage level (7)
- ☐ Self-regulation (8)

Display This Question:

If How are reading and writing interventions provided to your target students? Please select a choic... = They get writing intervention only.

Or How are reading and writing interventions provided to your target students? Please select a choic... = They get both reading and writing intervention time, delivered separately.

Q147 Do your students work on *reading* skills during their *writing* intervention?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Do your students work on reading skills during their writing intervention? = Yes

Q148 How many minutes of **each** *writing* intervention session do they work on *reading* skills, on average?

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Minutes ()	

End of Block: Reading and Writing Intervention - All Target Students

Start of Block: Reading and Writing Intervention - Target Student 1

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = No, my target students are not in the same reading and writing intervention groups.

Q162 Please enter your first target student's Early Writing Project ID.

_____

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = No, my target students are not in the same reading and writing intervention groups.

Q157 How are reading and writing interventions provided to this target student?
Please select a choice based on interventions, delivered in a small group/one-on-one format, as designated by a students' IEP services or RTI/MTSS tier.

- ○ They get writing intervention only. (1)
- ○ They get both reading and writing intervention time, delivered separately. (2)
- ○ They get a combined reading and writing intervention time. (3)

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get both reading and writing intervention time, delivered separately.

Q158 How many days per week do they receive *reading* intervention, on average?

0 1 2 3 4 5

Days ()

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get both reading and writing intervention time, delivered separately.

Q159 How many minutes is **each** reading intervention session, on average?

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Minutes ()

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get writing intervention only.

Or How are reading and writing interventions provided to this target student? Please select a choice... = They get both reading and writing intervention time, delivered separately.

Q160 How many days per week do they receive *writing* intervention, on average?

0 1 2 3 4 5

Days ()	

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get writing intervention only.

Or How are reading and writing interventions provided to this target student? Please select a choice... = They get both reading and writing intervention time, delivered separately.

Q161 How many minutes is **each** writing intervention session, on average?

0 5 10152025303540455055606570758085 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get a combined reading and writing intervention time.

Q162 How many days/week do they receive reading/writing intervention, on average?

0 1 2 3 4 5

Days ()	

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get a combined reading and writing intervention time.

Q163 How many minutes is **each** reading/writing intervention session, on average?

0 5 10152025303540455055606570758085 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get a combined reading and writing intervention time.

Q164 How many minutes of **each** reading/writing intervention session are spent on *reading* skills, on average?

0 5 10152025303540455055606570758085 90

Minutes ()	

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get a combined reading and writing intervention time.

Q165 How many minutes of **each** reading/writing intervention session are spent on writing skills, on average?

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Minutes ()	

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = No, my target students are not in the same reading and writing intervention groups.

Q166 Which reading skills are targeted in their reading and/or writing intervention? Check all that apply.

- ☐ Phonological/phonemic awareness (1)
- ☐ Decoding (2)
- ☐ Sight word reading (3)
- ☐ Reading fluency (4)
- ☐ Vocabulary (5)
- ☐ Reading comprehension (6)
- ☐ No reading skills are targeted (7)

Display This Question:

If Do all of your target students receive both reading and writing interventions in the same instruc... = No, my target students are not in the same reading and writing intervention groups.

Q167 Which skills are targeted in this student's reading and/or writing intervention? Check all that apply. *Please note: text generation = turning ideas into text; self-regulation = what writers do to meet their writing goals (e.g., planning, organizing, revising).*

- ☐ Handwriting (1)
- ☐ Spelling (2)
- ☐ Mechanics (3)
- ☐ Grammar/syntax (4)
- ☐ Text generation, word level (5)
- ☐ Text generation, sentence level (6)
- ☐ Text generation, passage level (7)
- ☐ Self-regulation (8)

Display This Question:

If How are reading and writing interventions provided to this target student? Please select a choice... = They get writing intervention only.

Or How are reading and writing interventions provided to this target student? Please select a choice... = They get both reading and writing intervention time, delivered separately.

Q168 Do your students work on *reading* skills during their *writing* intervention?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Do your students work on reading skills during their writing intervention? = Yes

Q169 How many minutes of **each** *writing* intervention session do they work on *reading* skills, on average?

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Minutes ()	

End of Block: Reading and Writing Intervention - Target Student 1

Note from author: Block repeated depending on how many students the teacher had in the project.

Display This Question:

If In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q196 Reading is relatively more important for my target students' career readiness than writing.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree or disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Display This Question:

If In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q197 My target students need significant support in reading.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree or disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Display This Question:

If In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q198 My target students need significant support in writing.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree or disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Display This Question:

If In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q199 I have enough instructional time available to deliver separate reading and writing interventions when my students need both.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Display This Question:

If In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q200 If I combined reading and writing activities into one literacy intervention, I would be able to address my students' reading and writing needs sufficiently.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Display This Question:

If In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q201 I wish the primary writing intervention program I used/created this year integrated more reading activities into lessons.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Display This Question:

If Were you part of the treatment or control group in the 2021-2022 cohort? = Treatment

And In this optional section of the survey, we're interested in learning more about whether, and how,... = Yes

Q202

Did you modify any of your students' WIPs to increase opportunities to read? Select all that apply.

- ☐ I adapted the mini-lessons to increase reading opportunities. (1)
- ☐ I increased reading opportunities as part of an intensification decision. (2)
- ☐ I integrated my own reading program/lessons into writing intervention time. (3)
- ☐ I did not modify WIPs to increase opportunities to read. (4)

End of Block: Reading and Writing Intervention - Teacher Beliefs

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Start of Block: End of Survey

Q127 Thank you for completing this survey! Additionally, thank you for your time and effort on The Early Writing Project. Your efforts will be of benefit to future teachers and students, and we greatly appreciate it!