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Exploring the Relation Between Teacher Factors and Student Growth in Early Writing

Britta Cook Bresina, MA[1]
and Kristen L. McMaster, PhD[1]

Abstract

Data from a small randomized control trial of teachers' use of Data-Based Instruction (DBI) for early writing were analyzed to determine the influence of teacher knowledge, skills, and treatment fidelity on student Curriculum-Based Measurement (CBM) slope. Participants included 11 elementary grade teachers who delivered intensive intervention in early writing and their students ($n = 31$), all identified as either at risk for or with disabilities that affect their writing. Teachers received professional development and ongoing coaching to support the implementation of DBI for improving their students' early writing skills. Results from a multiple regression analysis suggest that teacher knowledge and skills in DBI was strongly related to student CBM slope in early writing ($p < .01$) and a small but significant relation between fidelity of writing instruction and student CBM slope ($p < .01$). Implications for instructional coaching and improving student writing progress are discussed.

Keywords

CBM, professional development, written language

Learning to write is an important academic skill necessary for student success in both school and later life. Currently, many students with learning disabilities or other disabilities that affect academic performance struggle to develop their writing skills. According to the most recent national report on student writing, 60% of eighth-grade students with learning disabilities performed below a basic level in writing (National Center for Education Statistics, 2012). Many of these students will require intensive instruction for their writing skills to develop sufficiently (D. Fuchs et al., 2010; Zumeta, 2015).

Data-Based Instruction (DBI)

A growing body of research supports the use of DBI, also termed Data-Based Individualization (National Center on Intensive Intervention, 2013; also see Deno & Mirkin, 1977), to intensify and individualize instruction for students with significant needs (e.g., Coyne et al., 2013; Deno & Mirkin, 1977; McMaster et al., 2020) leading to improved student outcomes (Jung et al., 2018; Stecker et al., 2005), including improvements in early writing (Jung et al., 2017). DBI is a framework to guide teachers in taking a scientific approach to modifying instruction effectively and efficiently based on individual student need through the use of data. While there is variation in the literature regarding the specific steps of the DBI process, generally, DBI consists of the following core components: (a) identify a student's present level of performance, (b) set a long-term performance goal, (c) select and implement a research-based instructional platform and monitor progress often, (d) apply decision rules to the data to detect when instructional modifications are needed, (e) use data to hypothesize about the student's needs and make instructional changes accordingly, (f) monitor student progress in response to the instructional changes, and (g) repeat this process until the long-term goal is reached (Jung et al., 2018).

To monitor student progress and response to instruction for decision making in a DBI framework, research supports the use of Curriculum-Based Measurement (CBM; Deno, 1985). CBM marries measurement and instruction by providing teachers with a way to frequently and repeatedly measure student performance in a domain (e.g., writing) in a quick and easy-to-understand manner that has been shown to produce reliable and valid estimates of student growth (Deno, 1985). Researchers have shown that teachers' use of CBM data to inform their instruction can increase teacher

[1]University of Minnesota, Minneapolis, USA

Corresponding Author:
Britta Cook Bresina, MA, Department of Educational Psychology, University of Minnesota, Education Sciences Building, 56 E. River Road, Minneapolis, MN 55455, USA.
Email: bresi016@umn.edu

effectiveness and student achievement (L. S. Fuchs et al., 1984; Jung et al., 2018; Stecker et al., 2005). Specific to writing, multiple CBM-Writing tasks are empirically supported for progress monitoring. For early writing, CBM-Writing word dictation, picture word, and story prompts have empirical evidence supporting their use (for a review of these and other early writing tasks, see McMaster, Ritchey, & Lembke, 2011). These CBM-Writing tasks are used to measure word-, sentence-, and passage-level writing, respectively.

Teacher Knowledge and Skills

Persistent low achievement of students at risk for or identified with disabilities suggests that schools struggle to provide sufficiently intensive instruction for these students to prosper (McInerney et al., 2014; Zumeta, 2015). The degree to which teachers are currently individualizing and intensifying instruction to meet the needs of struggling learners varies greatly (Lemons et al., 2016). Furthermore, the success of this individualization and intensification appears to be influenced by both teachers' knowledge of how to effectively and systematically intensify instruction for the individual learner and teachers' literacy content knowledge (e.g., Cunningham et al., 2004; Spear-Swerling & Zibulsky, 2014).

Cutler and Graham (2008) conducted a national survey of elementary teachers' writing knowledge and instructional practices. When asked how adequate teachers felt their pre-service education was in equipping them with the necessary skills and knowledge to effectively deliver writing instruction, a minority described their pre-service education to be above adequate with about one quarter of the teachers surveyed finding their pre-service education to be greatly lacking (i.e., rated as poor), while just under half found their pre-service education to be simply adequate. These findings align with the conclusions from the National Commission on Writing (2003), which describes the neglect of writing in today's classroom instruction and claims that many teachers are insufficiently equipped to teach writing.

In another study where teachers were given free-rein to design a 2-hr language arts instructional block however they wished, Spear-Swerling and Zibulsky (2014) found that teacher knowledge in literacy instruction positively predicted whether the teachers chose to include research-based instructional features (e.g., vocabulary, writing assessment, basic writing skills) into their lessons. Nevertheless, many research-based instructional features *were still absent* in the majority of the lessons that teachers created. Specifically for writing instruction, basic writing skills instruction and writing assessment were limited or nonexistent in the majority of the teachers' instructional plans despite the importance of early writing instruction (e.g., Berninger, 2009). Thus, there is a need for continued in-service teacher professional development and the implementation of research-based curriculum in schools (Spear-Swerling and Zibulsky, 2014).

Coaching and Fidelity of Implementation

To support teachers in developing and sustaining the necessary knowledge and skills required to successfully implement a new practice, such as DBI, professional development coupled with ongoing coaching shows promise of effectiveness (see Kraft et al., 2018, for a meta-analysis). For example, Kretlow et al. (2011) and Kretlow et al. (2012) found that training alone (i.e., increased teacher knowledge) was insufficient to increase teachers' correct use of research-based practices consistently; individualized coaching was required for such practices to be accurately implemented. This outcome is likely because teachers typically require more than increased knowledge to update their instructional practices (e.g., Desimone, 2002; also see Kretlow & Bartholomew, 2010, for a review of coaching).

The National Center for Systematic Improvement (n.d.) states the purpose of instructional coaching is to support teachers in implementing new skills or practices that have evidence of high effectiveness, with fidelity, for the purpose of improving student outcomes (Kretlow & Bartholomew, 2010; Snyder et al., 2015). Fidelity of implementation (also termed treatment fidelity, treatment integrity, or procedural reliability; Gresham et al., 2000) indicates the extent to which key features of an intervention are implemented as intended (Gersten et al., 2005). Fidelity of implementation is a critical concern among researchers and practitioners alike. Unfortunately, few empirical studies of coaching have included outcome measures of student achievement (Kretlow & Bartholomew, 2010; Marsh et al., 2010). However, evidence supports the notion that student learning can be largely and positively affected by teachers' increased use of evidence-based practices with high fidelity of implementation, and that these teacher behaviors can be supported through coaching (Kretlow & Bartholomew, 2010). Furthermore, when considering intensive interventions and the relation between fidelity and student response to intervention, factors such as student engagement with and exposure to the intervention may be integral (Johnson & McMaster, 2013).

Whereas evidence supports the use of coaching, more research is needed to understand how to optimize its efficacy and efficiency. Because improved student outcomes is usually the ultimate goal of coaching and given the high demands of being a teacher, focusing coaching sessions to be optimally effective and efficient is important.

Links have been identified between instructional practices, various teacher factors, and students' writing improvement. Although not structured within a coaching context, teachers' instructional quality, specifically their responsiveness, has been shown to be related to written composition of first-graders, even when accounting for various student-level factors. Meanwhile, other teacher factors such as quality of individualization or the teacher's ability to provide explicit, well-structured literacy instruction were not found to be significantly related to student written composition while accounting for multiple other student- and classroom-level predictors (Kim et al., 2013). Within a coaching context, researchers have investigated the relation between various teacher factors, coaching, and student achievement. Marsh et al. (2010) found a relation between the frequency with which teachers received coaching that supported their use of data and student achievement in reading and math. Wayne and Youngs (2003) reviewed the literature on teacher characteristics and student achievement gains on standardized tests. They categorized the teacher factors into the following: the rating of teachers' undergraduate institutions, teacher test scores, degrees and coursework, and certification status. Results suggested a positive relation between teachers' college rating and test scores on student achievement while teachers' degrees, coursework, and certifications suggest an inconclusive relation to student achievement with the exception of a positive relation within the domain of mathematics.

While previous studies have examined the relation between teacher factors and increased student achievement, many of these studies have focused on factors such as teacher level of education and certification(s) held (see Wayne & Youngs, 2003, for a review). However, such factors are not amenable to the types of changes that coaching can facilitate; in other words, they would not be malleable to a coaching intervention. Therefore, more information is needed to better understand the strength of the relations among teacher factors that might be more readily influenced by coaching (e.g., teacher knowledge, skills, fidelity) and student outcomes so that coaching activities can target the most relevant factors. The present study adds to this literature by addressing the relation between teacher knowledge, skills, and fidelity, and student CBM slope. Specifically, we assess teacher factors associated with DBI (i.e., DBI knowledge and skills; fidelity of implementation of DBI components, including CBM administration, writing instruction, and instructional decision making) that can be directly addressed during instructional coaching and that may influence the CBM-Writing slope of students with severe learning needs. Therefore, this study should be viewed as an exploratory investigation intended to inform future research addressing how to optimize coaching supports to improve teaching and result in greater outcomes in student writing.

Theory of Change

All data in the current study were drawn from a larger study (McMaster et al., 2020) where teachers were provided professional development through the implementation of Data-Based Instruction: Tools, Learning, and Collaborative Supports (DBI-TLC; Lembke et al., 2018) to support them in learning about and using DBI for students at risk for or identified with disabilities that affect their early writing skills. Through DBI-TLC, teachers received professional development, ongoing coaching, and materials for assessment and instruction. For this study, an eight-step approach to DBI was adopted: (a) determine the student's present level of performance, (b) set a long-term goal that is both achievable and ambitious, (c) deliver high-quality instruction with fidelity that is matched to student need, (d) frequently monitor student progress toward the goal, (e) gauge instructional effectiveness and student progress by applying decision rules, (f) create hypotheses about student progress, (g) test the hypotheses to individualize instruction by making an instructional change, and (h) repeat as necessary (Lembke et al., 2018; McMaster et al., 2020).

The following theory of change guided this work. We posit that by providing comprehensive professional development with ongoing coaching support, teachers' knowledge and skills of DBI and early writing instruction would improve, leading to greater fidelity of implementation of DBI components, ultimately leading to improved student outcomes. This theory of change has been slightly altered from that of McMaster et al. (2020) to better match the current study. In McMaster et al. (2020), the theory of change included that teacher participation in DBI-TLC would also lead to improvements in their self-efficacy, leading to increased fidelity, and ultimately increased student achievement. However, in the current study, teachers' self-efficacy was not included for two main reasons. First, examining teacher self-efficacy is beyond the scope of this study as the focus is on teacher factors related to knowledge and implementation—factors that might be more directly affected through coaching and that were the focus of coaching sessions during the larger study. Second, the small sample size, particularly the number of teachers, did not allow for all available teacher factors to be included in the model. Furthermore, the results of McMaster et al.'s study showed no significant mean group differences between treatment and control teachers for self-efficacy suggesting that, at least with these data, teachers' self-efficacy was not noticeably changed as a result of the intervention. However, there was a significant main effect of knowledge and skills showing improved knowledge and skills of DBI for treatment teachers (g = 2.88; McMaster et al., 2020). Finally, although it is likely that teachers' self-efficacy indeed can be influenced by coaching and may play an important role in student learning (e.g., Armor et al., 1976), as hypothesized by McMaster and colleagues, it is also quite possible that there are differences in self-efficacy between individuals who elect to participate in research studies compared with those who do not (e.g., Graham et al., 2001; Troia et al., 2011), therefore limiting the generalizability of such findings. For all of these reasons, self-efficacy was not included in the current study.

Purpose and Research Question

The purpose of this investigation was to explore the relation between teacher factors and student rate of improvement in early writing. In the interest of optimizing coaching to lead to a greater chance of student improvement, knowing which malleable teacher factors may be most influential to achieving this end is necessary. The specific research question addressed in this study is as follows:

> **Research Question 1:** What is the relative strength of the relation between teacher factors (i.e., teachers' DBI knowledge and skills, fidelity of implementation in CBM administration, writing instruction, and instructional decision making) and students' rate of improvement in early writing as measured by CBM-Writing tasks?

Method

All data used in the current study were drawn from a larger study assessing the feasibility and promise of a professional development program designed to support teachers' use of DBI (McMaster et al., 2020). This larger study involved a small pretest/posttest randomized control trial (RCT) group design in which teachers were randomly assigned to treatment (in which they received DBI-TLC and implemented DBI for 20 weeks) or a business-as-usual control group. All teacher participant data included in the current study were from RCT treatment group teachers.

Participants

Participants included 11 elementary special education teachers from two school districts (one urban and one small city; see Table 1 for teacher demographic data) in two Midwestern states and a subset of their students (n = 31; see Table 2 for student demographic data). Teacher participants needed to have a minimum of 2 years of teaching experience and directly provide instruction in early writing to the student participants. All students were at risk for or identified with mild to moderate disabilities that affected their writing and subsequently received intervention for early writing skills. Students were primarily in Grades 1 to 3 with some in Grades 4 and 5. Students were nominated for study participation by their teachers. Following nomination, students were administered CBM-Writing probes: two word dictation and two picture word (described in the "Measures" section). The two to three lowest scoring students from each teacher were selected for study participation (see McMaster et al., 2020, for more specifics regarding participant inclusion).

Intervention

Data-Based Instruction: Tools, Learning, & Collaborative Supports. DBI-TLC is a professional development program to develop

Table 1. Teacher Demographics.

Demographic	DBI-TLC Teachers (n = 11)
Gender	
Female	11 (100%)
Male	0 (0%)
Ethnicity	
White/European American	11 (100%)
Age	
20–29	2 (18%)
30–39	3 (27%)
40–49	5 (45%)
50–59	1 (9%)
Highest degree	
Bachelor's	4 (36%)
Master's	3 (27%)
Master's + coursework	4 (36%)
Current job title	
Special education teacher	10 (90%)
	M (range)
Years teaching special education	9.68 (1–22 years)

Note. Due to rounding, percentages may not sum to 100.

Table 2. Student Demographics.

Demographic	DBI-TLC Students (n = 31)
Gender	
Female	17 (55%)
Male	14 (45%)
Ethnicity	
Black/African American	4 (13%)
Hispanic/Latino(a) American	2 (6%)
White/European American	22 (71%)
Multiracial	3 (10%)
Free/reduced lunch	21 (68%)
English-language learners	6 (19%)
IEP/special education	30 (97%)
Special education category	
Autism	8 (26%)
Emotional/behavioral disorder	1 (3%)
Learning disability	8 (26%)
Language impairment	5 (16%)
Hearing impairment	1 (3%)
Other health disability	4 (13%)
Needing alternative programming	3 (10%)
	M (*SD*)
Age	9.12 (1.41)

Note. Due to rounding, percentages may not sum to 100. IEP = Individualized Education Plan.

teachers' knowledge of DBI and support their implementation of DBI for students at risk for or identified with disabilities that affect their writing. During the RCT, researchers provided treatment teachers with materials for and instruction on the use of DBI during 4 full-day workshops. Teachers implemented DBI with biweekly coaching support for 20 weeks. The workshops focused on the following topics: (a) CBM administration, scoring, and graphing; (b) selecting and implementing research-based instructional mini-lessons that target individual student needs; and (c) using data to make instructional decisions. This knowledge base became the foundation for teachers to implement the DBI process, with coaching support, in their classrooms. The researchers encouraged the teachers to deliver individualized lessons at least 3 times per week for 20- or 30-min intervention sessions; however, dosage and duration were ultimately determined by each teacher based on student need. The results of the RCT from which data for the current study were drawn showed that students of DBI-TLC treatment teachers improved in their writing performance (effect sizes of 0.23–0.40) as measured by CBM-Writing tasks (McMaster et al., 2020).

Coaching. The purpose of the coaching sessions was to support teachers in their implementation of DBI. All participating teachers received one-on-one biweekly coaching throughout the duration of the study; coaching averaged 40 min per session ($SD = 16.10$). Each coaching session consisted of the following activities: (a) celebration and commiseration (to build relationships), (b) summarization of the previous meeting, (c) identification of objectives for the current meeting, (d) viewing of performance measures, (e) summarization of the meeting, (f) planning for the next meeting, and (g) identification of tasks to be completed by the coach and teacher prior to the next meeting. Additional coaching session topics included looking at permanent products regarding (a) teachers' CBM administration, CBM scoring reliability, and CBM graphing; (b) instructional dosage log; (c) writing instructional plan (WIP) creation, administration, and fidelity; and (d) looking at individual student progress monitoring graphs to assess growth and make instructional decisions.

All coaches were either graduate research assistants (advanced doctoral students in special education or school psychology) or project coordinators (all with advanced degrees in special education, school psychology, or administration). Coaches were trained by the co-principal investigators by way of a 2-hr workshop, which included modeling and guided practice on principles of coaching, positive coaching, differentiating coaching, and the study-specific coaching protocols (see McMaster et al., 2020). Coaches also attended weekly meetings to problem solve with the principal investigators on how to best support their teachers. Fidelity of coaching was measured with a checklist that aligned with the above-mentioned coaching activities. Principal investigators and project coordinators observed each coach twice, once earlier and once later in the 20 weeks of implementation. Coaching fidelity score was expressed as a percentage of coaching activities observed. Mean fidelity score for coaching was 94% (range = 71%–100%).

Measures

Student outcome. Teachers used one of three CBM-Writing tasks to monitor student progress, either CBM-Writing word dictation, picture word, or story prompts depending on the student's specific level of performance. To enable comparisons across task types, CBM-Writing scores were converted to scale scores for the purpose of this study. This procedure is described in more detail below under the "Data Analysis" section.

Each CBM-Writing task was either administered individually (word dictation) or group-administered (picture word and story prompt). Students were given 3 min to complete the probes, which were given weekly during the course of the study by their teacher. Student CBM-Writing samples were scored using quantitative indices which are described below in more detail for each measure. These measures have empirical evidence supporting their use with early writers (McMaster, Ritchey, & Lembke, 2011) and, when administered weekly, have been shown to be sensitive to student writing growth within 8 weeks (Hampton & Lembke, 2016; McMaster, Du, et al., 2011). Further psychometric information is detailed below.

CBM-Writing word dictation. This task measures writing skills at the word level. To administer, a list of words containing specific spelling patterns (taken from the Common Core State Standards, National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) is read aloud, with one repeat. Students write the dictated words. Written responses are scored for the total number of words written, words spelled correctly, correct letter sequences (i.e., any two sequential letters in a word that are appropriately placed to correctly spell the word), and correct minus incorrect letter sequences. Alternate form reliability for Grades 1 to 3 has been found to be $r = .89$ to .95 (Lembke et al., 2003, 2015). For the current sample, alternate form reliability coefficients were $r = .94$ to .96 (pretest; median = 0.95) to $r = .92$ to .96 (posttest; median = 0.94) (McMaster et al., 2020).

CBM-Writing picture word. This task measures sentence-level writing skills. Students are given writing prompts which are a series of words accompanied by pictures. A practice item is included. Written responses are scored for total words written, words spelled correctly, correct word sequences (i.e., any two sequential words that are spelled, punctuated, and used correctly within the context of the writing), and correct minus incorrect word sequences. Alternate form reliability for Grades 1 to 3 has been found to be $r = .50$ to .60 (Lembke et al., 2015; McMaster et al., 2009). For the current sample, alternate form reliability coefficients were $r = .81$ to .91 (pretest; median = 0.85) to $r = .86$ to .90 (posttest; median = 0.87) (McMaster et al., 2020).

CBM-Writing story prompt. This task measures writing skills at the paragraph level. To administer, students are given a writing prompt which is a sentence or the beginning of a sentence, written in age-appropriate language, structure, and content. Students are given 30 s to plan their writing before they begin to write their story. Written responses are scored for total words written, words spelled correctly, correct word sequences, and correct minus incorrect word sequences. Alternate form reliability for Grades 1 to 3 has been found to be $r = .74$ to .88 (Lembke et al., 2015). For the current sample, alternate form reliability coefficients were $r = .71$ to .89 (given only at posttest; median = 0.82; McMaster et al., 2020).

Teacher factors. Teachers were pre- and posttested on their DBI knowledge and skills and assessed in their fidelity of components of DBI implementation. As previously stated, not all possible teacher factors measured in the RCT were included. Thus, teachers' posttest scores on DBI knowledge and skills, and fidelity for implementing three key components of the DBI framework—writing instruction, CBM administration, and decision making—were entered into the analysis. Given that these four teacher factors could potentially be directly affected through coaching and were the focus of the coaching sessions in the RCT, an understanding of the extent to which they are related to increased writing achievement for students with disabilities is important to optimize coaching effectiveness.

DBI knowledge and skills. Teachers' DBI knowledge and skills were measured both pre- and post-intervention by a 40-question multiple choice assessment that was developed for use in the RCT (for more specifics, see McMaster et al., 2020). This assessment is designed to gauge teachers' knowledge of DBI. Questions target the purpose of DBI, the DBI framework, progress monitoring, development and instruction of writing, CBM administration and scoring, and using CBM data within the DBI framework to make appropriate and timely instructional decisions for the individual student. An example question measuring a teacher's knowledge of DBI would be, "Who should receive DBI?" whereas an example question measuring a teacher's skills associated with DBI would be to have the teacher examine a progress monitoring graph of CBM data and then apply a decision rule to make a decision. For the current sample, Cronbach's alpha of .58 (pretest) to .78 (posttest) was calculated (McMaster et al., 2020). Only teachers' post-intervention scores (total correct) were used in the current analysis because they represent treatment teachers' DBI knowledge and skills following professional development and coaching.

Fidelity measures. Fidelity of implementation was measured on three key components to the DBI framework: CBM administration, writing instruction, and decision making (see the appendix for fidelity measures). For each fidelity of implementation area, McMaster et al. (2020) created a checklist that entailed the essential components of that area and were scored based on whether or not the specific behavior was observed during the observation period. Fidelity measures were modeled after the *Accuracy of Implementation Rating Scale* (AIRS; L. S. Fuchs et al., 1984), which was created for the purpose of assessing DBI fidelity.

The CBM fidelity checklist measured CBM administration, scoring, and graphing. The writing instruction fidelity checklist measured key instructional components such as motivation, modeling, guided practice, and independent practice. Teachers delivered instruction by following WIPs (McMaster et al., 2020), which are comprised of research-based early writing mini-lessons. Teachers were taught to use the Simple View of Writing (Berninger et al., 2002) framework when planning a WIP, which allows for them to piece together an instructional plan that covers the specific writing needs of their individual students across the areas of transcription, text generation, and self-regulation. The decision-making fidelity checklist measured teachers' use of DBI decision rules to make a timely (i.e., made after six to eight data points were collected) and appropriate (i.e., aligned with student data) instructional decision (i.e., raise the goal, modify instruction, keep instruction as-is).

Throughout the 20 weeks of DBI implementation, one or two fidelity checks were performed per teacher for writing instruction and CBM administration by the co-principal investigators while decision making was measured once (McMaster et al., 2020). A paired-samples t test was run to see whether the repeated measurement of writing instruction fidelity significantly differed from Timepoint 1 to Timepoint 2. Results suggest no statistically significant difference between timepoints ($t = 0.098$, $df = 8$, $p > .9$). A paired-samples t test of CBM administration also suggested no statistically significant difference between timepoints ($t = -1.175$, $df = 2$, $p > .3$). Therefore, to maintain maximum teachers for the analysis, each teacher's mean writing instruction fidelity and CBM administration fidelity was used, if more than one observation had been completed per measure.

Data Analysis

For the purpose of this study, scale scores were calculated for all three CBM-Writing tasks, maintaining a

Table 3. Descriptive Statistics for Student CBM-Writing Measures.

CBM-writing	Scoring	Raw score range (scale score)	Raw score mean (scale score)	Raw score *SD* (scale score)
Picture word	Words spelled correctly	6.00–49.00 (76.26–126.11)	27.53 (101.19)	8.27 (9.52)
Picture word	Correct word sequences	4.00–55.00 (78.03–132.02)	23.24 (98.40)	11.52 (12.19)
Word dictation	Correct letter sequences	0.00–166.50 (68.77–114.14)	55.92 (84.01)	29.79 (8.11)
Story prompt	Correct word sequences	1.00–73.00 (78.58–172.66)	16.99 (99.02)	15.46 (19.88)

Note. CBM = Curriculum-Based Measurement.

Table 4. Correlations.

Variable	*CBM*	*Baseline CBM*	*Weeks DBI*	*Post K&S*	*Write Fid*	*CBM Fid*	*DM Fid*
CBM	1.000						
Baseline CBM	.645	1.000					
Weeks DBI	.245	<−.001	1.000				
Post K&S	.017	−.411	<−.001	1.000			
Write Fid	−.064	−.363	<−.001	.608	1.000		
CBM Fid	−.282	−.489	<−.001	.234	.284	1.000	
DM Fid	.213	.271	<.001	.278	−.419	−.398	1.000

Note. CBM = students' weekly CBM-Writing scores for each week; *Baseline CBM* = students' baseline score; *Weeks DBI* = the number of weeks of instruction (20 for all); *Post K&S* = teachers' posttest DBI knowledge and skills; *Write Fid* = teachers' writing instructional fidelity score; *CBM Fid* = teachers' CBM administration fidelity score; *DM Fid* = teachers' instructional decision-making fidelity score.

normal distribution. To create the scale scores, unpublished benchmarking data (Lembke et al., 2015) on 603 students in Grades 1 through 3 were used. Means and standard deviations were calculated on all three CBM-Writing tasks that were then linearly transformed to set the mean at 100 and *SD* at 15. These results were used as the template to then convert the data used in the current study to scale scores (e.g., if the CBM picture-word benchmarking mean was 10 and the *SD* was 2.5, then a score of 10 becomes 100 and a score of 12.5 becomes 115). This conversion allows for comparisons across measures given that teachers used different CBM-Writing tasks for different students.

Given the research question regarding student rate of improvement and the nested structure of the data, a longitudinally designed hierarchical linear model (HLM; Raudenbush & Bryk, 2002) would have been the ideal way to model these data. However, the small sample size did not allow for HLM. Instead, a multiple regression analysis was performed. Linear regression assumptions were assessed and deemed to be met. The repeated measurement of students' weekly CBM-Writing scale scores over 20 weeks of instruction (CBM) was regressed on the students' baseline CBM score ($Baseline\ CBM$), weeks of DBI intervention students received ($n = 20$) ($Weeks\ DBI$), teacher posttest DBI knowledge and skills score ($Post\ K\ \&\ S$), teacher writing instruction fidelity score ($Write\ Fid$), teacher CBM-Writing administration fidelity score ($CBM\ Fid$), and teacher decision-making fidelity score ($DM\ Fid$). Specifically, the outcome of interest was student rate of improvement rather than simply absolute growth as the goal of DBI is to increase a student's rate of improvement (i.e., the slope of the trend line of their CBM graph). Therefore, the outcome of the regression model was the repeated measurement of CBM-Writing over time for each student. Also, although all students received the same number of weeks of DBI, the number of weeks of instruction was entered into the model to adhere to longitudinal modeling techniques and to control for instructional time. Given that the research question focused on the extent to which teacher factors related to student early writing slope, all predictors were entered into the model at once.

$$CBM = \beta_0 + \beta_1 (Baseline\,CBM) + \beta_2 (Weeks\ DBI) + \beta_3 (Post\ K\ \&\ S) + \beta_4 (Write\ Fid) + \beta_5 (CBM\ Fid) + \beta_6 (DM\ Fid) + \epsilon$$

Results

While complete data were available for all 11 teachers in the study, resulting in no teacher attrition, missing student data due to absences or moving resulted in the original 36 students of treatment teachers being reduced to a total of 31 students included in the analysis.

Descriptive statistics for the three CBM-Writing tasks can be found in Table 3. For correlations between all teacher measures and student CBM-Writing scores, see Table 4.

Fidelity observations revealed that DBI teachers reliably administered weekly CBM-Writing probes with a mean of 84% accuracy ($SD = 14.7\%$). In addition, every month, each

Table 5. Regression Output for Student CBM-Writing Regressed on Teacher Factors.

Variable	β	*SE*	*p* value
Intercept	−130.91	16.07	<.001
Baseline CBM	0.97	0.08	<.001
Weeks DBI	0.54	0.08	<.001
Post K&S	5.74	0.66	<.001
Write Fid	−0.55	0.14	<.001
CBM Fid	−0.01	0.06	.87
DM Fid	−0.13	0.08	.11

Note. Model-level statistics: $F(6, 286) = 80.47$, $p < .001$, $R^2 = .63$. *Baseline CBM* = students' baseline score; *Weeks DBI* = the number of weeks of instruction (20 for all); *Post K&S* = teachers' posttest DBI knowledge and skills; *Write Fid* = teachers' writing instructional fidelity score; *CBM Fid* = teachers' CBM administration fidelity score; *DM Fid* = teachers' instructional decision-making fidelity score.

teacher's coach double-scored a minimum of 10% of the CBM-Writing probes and calculated interrater agreement in scoring (M = 95%). Teachers' fidelity of writing instruction was 79% (SD = 14%), and fidelity of overall decision making was 52% (SD = 38%). Teachers' posttest DBI knowledge and skills mean score was 32 (SD = 2.2) out of a total of 40 points. Results of the multiple regression analysis showed the model accounted for about 63% of the overall variance in student growth (R^2 = .628). See regression results in Table 5. Specifically, main effects for student baseline CBM score ($\beta = 0.97$, $p < .001$), the number of weeks a student received DBI intervention ($\beta = 0.54$, $p < .001$), their teacher's posttest DBI knowledge and skills assessment score ($\beta = 5.74$, $p < .001$), and their teacher's writing instructional fidelity score ($\beta = -0.55$, $p < .001$) were statistically significant predictors of the student writing outcome. Measures of CBM and decision-making fidelity did not significantly predict the student writing outcome.

Discussion

The purpose of this investigation was to explore the strength of the relation between teacher factors (i.e., teachers' DBI knowledge and skills, fidelity in CBM administration, writing instruction, and decision making) and student slope in early writing. To help support special education teachers in successfully implementing newly learned instructional strategies that have evidence of leading to improved student outcomes, it is essential that coaches are effective and efficient in their support. Therefore, to optimize coaching, the identification of malleable teacher factors which, if addressed during coaching, are related to the greatest rate of student improvement is needed.

Results from the analysis that regressed student CBM-Writing scores over a 20-week period on teacher factors suggest a significant positive relation between teacher knowledge and skills of the DBI framework and rate of improvement in early writing for students with intensive needs, even when controlling for baseline CBM-Writing. Specifically, higher teacher knowledge and skills was related to greater student slope. This finding aligns with previous research showing the efficacy of DBI to improve student outcomes (Jung et al., 2018; Stecker et al., 2005), the positive effect of coaching on student achievement (Kraft et al., 2018), and the benefit of teachers' increased knowledge of evidence-based practices, supported through coaching, on student achievement (Kretlow & Bartholomew, 2010). Moreover, these results appear to support our theory of change that there is a progression of teacher skill acquisition that leads to improved student outcomes. Note that, whereas previous research suggests increases in knowledge alone does not improve teacher performance (e.g., Kretlow et al., 2011), the relation here is between a combined score of knowledge and skills supported through coaching as opposed to improved knowledge alone. There was also a significant effect of weeks of DBI, suggesting that, on average, students experienced a statistically significant increase in their rate of improvement in CBM-Writing over the course of the 20 weeks of intervention.

Although our theory of change suggests implementation with fidelity should affect student slope, the results obtained from this investigation suggest that fidelity may be relatively less important to student slope in early writing than weeks of instruction and teacher posttest DBI knowledge and skills when modeled together and when controlling for baseline CBM-Writing. Interestingly, although writing instructional fidelity was a significant predictor of student outcome, it had a relatively small and negative relation with student rate of improvement such that every 1-point increase in teacher writing instructional fidelity is associated with a decrease of 0.55 units in student CBM-Writing. This particular result does not align with previous research that suggests an important positive relation between fidelity and student outcomes (e.g., O'Donnell, 2008). However, these results should be interpreted with caution for several reasons.

First, teachers implemented the intervention for a total of 20 weeks, which may not have been a sufficient amount of time for meaningful change to happen across all areas identified within our theory of change. While teachers' DBI knowledge and skills improved from pre- to posttest and was substantially higher than that of control teachers (Hedges's $g = 2.88$; McMaster et al., 2020), there may have been an insufficient amount of time for this increase in knowledge and skills to influence fidelity, suggesting a progressive nature to skill development among the specific skills measured. Other researchers have found that a large amount of professional development and instructional practice appears to be needed (i.e., 80 or more hours) before a teacher is likely to appropriately implement a new skill (Corcoran et al., 2003).

Second, it could be that the theory of change proposed is incorrect. Perhaps improving teachers' knowledge and skills of DBI coupled with coaching is enough, in certain circumstances, to increase student rate of improvement with sufficient increases in fidelity possibly serving as an additional boost to student outcomes. Given that many teachers report limited pre-service preparation on instructing students in writing and that observational studies have suggested that minimal time is devoted to writing instruction and practice in elementary grades (Cutler & Graham, 2008), it is conceivable that the increased teacher knowledge and skills of DBI for early writing indeed did lead to improved student outcomes, in the absence of an effect of fidelity. This could be because the increased knowledge and skills led to the teachers teaching necessary basic writing skills to their students, which appear to not have been happening prior to the study. Evidence of this possibility can be found from data collected during the McMaster et al. (2020) RCT where observations of the control group showed that control teachers typically taught writing for 20 to 40 min per day but that this instruction rarely included skill instruction in basic writing.

Last, it is possible that the measures used to quantify fidelity of implementation may not have been sensitive enough to teacher growth or may not have adequately captured fidelity, effectively not showing any relation, should one exist, between fidelity and student growth in early writing within the context of the current study. Particularly relevant are the issues surrounding the measurement of fidelity of implementation for an intervention that is meant to be individualized and intensified (see Sanetti & Kratochwill, 2009, for a discussion) such as was the case with DBI-TLC. Although high adherence to fidelity has been shown to increase student outcomes (O'Donnell, 2008), for students who most struggle, a lack of appropriate individualization of instruction could stifle student growth (e.g., Wanzek & Vaughn, 2009). At the core of DBI is the use of instructional modifications to improve student outcomes that are determined through the use of data (Deno & Mirkin, 1977; Jung et al., 2018). Therefore, modifications to the base instructional plan are an expectation. Thus, when measuring fidelity of *intensive* intervention, strict adherence to a general checklist of instructional components is likely insufficient and other components of fidelity should be considered (Johnson & McMaster, 2013; Sanetti & Kratochwill, 2009). One such component may be student response to and engagement with the instruction (O'Donnell, 2008; Sanetti & Kratochwill, 2009).

Of course, all the above explanations are somewhat speculative and require further research to answer more conclusively.

Limitations and Future Research

Limitations of the current study largely center on its exploratory nature. In particular, the sample size of participants was insufficient to construct a more desirable statistical model that would account for the nested structure of the data. Given that a multiple regression model was fit instead of an HLM, variance specific to the teacher or student levels could not be parsed. Relatedly, although it was outside the scope of the current investigation, another limitation is that not all possible teacher-level factors from the McMaster et al. (2020) theory of change—namely, teacher self-efficacy—were included in this study. Future research should include a broader range of relevant teacher factors, such as self-efficacy, to address how these factors may be related to student outcomes. The measurement of teachers' DBI knowledge and skills as one combined score rather than as separate scores is also a potential limitation. Knowledge and skills, while related, are separate constructs and may differentially affect student rate of improvement in early writing. However, for the purposes of the larger study, knowledge and skills were measured together as a way to gauge teachers' understanding of foundational DBI knowledge and how to apply that knowledge. Future research should parse these constructs to investigate their unique relation to student CBM slope.

Due to no control group of students being included in the current study, we are unable to conclude that the significant effect of weeks of DBI means there was statistically significant growth in CBM-Writing for students as a result of receiving DBI beyond what would be expected from maturation. Although the question of the effectiveness of DBI in leading to improved student outcomes was beyond the scope of this study, it is helpful to note that during the RCT from which these data were drawn, results showed stronger writing performance for students of the treatment teachers on CBM-Writing than for students of control teachers (effect sizes of 0.23–0.40; McMaster et al., 2020). For the purposes of the current study, weeks of DBI was entered into the model simply to control for the fact that the outcome was a repeated measure gathered across time.

Finally, the adequate measurement of fidelity is a limitation given that some fidelity measures, especially for writing instruction, appeared to not be sensitive to intensive intervention as indicated by the fact that the fidelity measures were used to monitor treatment teachers and control teachers during the pilot study of DBI-TLC but failed to differentiate between the two groups (Lembke et al., 2018). In other words, the fidelity measures appeared to fail to capture possible nuances of *intensive* intervention.

As a result of the current study, important questions arise that require future investigation. For instance, future research should further explore the relation between relevant teacher factors, both those investigated here and others, and how they are related to and may affect CBM slope in early writing for students who most struggle. Given empirical support that high implementation fidelity is related to improved student outcomes (Kretlow & Bartholomew, 2010), the results of the current analysis beg the question of whether fidelity of implementation was measured in a sensitive enough manner to validly capture fidelity of *intensive* intervention. Specifically, given the purpose of DBI is to support teachers in taking a scientific approach to their teaching by systematically gathering data and making instructional decisions to effectively intensify and individualize instruction, perhaps the current measure of writing instructional fidelity captured principles of good instruction but not necessarily *intensive* instruction, as evidenced by the inability of this measure to distinguish between treatment and control teachers during a pilot study of DBI-TLC (Lembke et al., 2018) where presumably the treatment teachers were delivering more highly intensified instruction (i.e., through DBI) than controls. Regarding the unexpected results suggesting a small, negative relation between fidelity of writing instruction to student outcomes and no relation between CBM administration and DBI decision making to student outcomes, further research is needed to address how to more adequately measure fidelity of implementation for intensified interventions, such as DBI, and what the important aspects of an intensive intervention are that set it apart from a nonintensive intervention.

Conclusion

Many students with disabilities struggle to learn to write and require intensive, individualized instruction to progress in their skills. DBI is a systematic framework that helps teachers gather data to make informed, instructional decisions to intensify and individualize their instruction. Therefore, supporting teachers' implementation of DBI is important (e.g., Jung et al., 2018). Effectiveness and efficiency with coaching are essential to optimize the support provided to teachers and, in turn, optimize student growth. But to be effective and efficient in supporting teachers, coaches must know which specific teacher factors are related to greater student rate of improvement in early writing. The results of the current study are exploratory and provide insight into the importance of supporting teachers' understanding of the DBI framework to support student rate of improvement in early writing and suggest the need for careful considerations to be made when measuring fidelity of *intensive* intervention.

Appendix

AIRS—CBM-W: Picture-Word Prompt

Implementer:	Observer/rater:
Date:	
Start time:	End time:

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.

	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 in front of each student				
b. Presents an example of a picture-word prompt				
c. Demonstrates how students should complete the entire picture-word task with the sample copy				
d. Reminds students to do their best work				
e. Demonstrates how to deal with spelling difficulties while taking test				
f. Reads each word on the picture-word task				
g. Prompts students to continue working until the timer rings, if necessary				

(continued)

Appendix (continued)

	Yes 1	No 0	N/A	Observation notes
3. Overall demonstration skills				
a. Reads directions accurately				
b. Demonstrates by pointing when appropriate				
c. Pauses for questions				
4. Timing				
a. Says "Please begin writing"				
b. Starts/stops timer at the correct times				
c. Times students for 3 min				
d. Says "Stop. Raise your hand with your pencil in it"				
e. Marks administrator copy as needed				

Part II. Scoring the Assessment. Check the implementer's scoring for accuracy.

	Yes 1	No 0	N/A	Observation notes
Scoring for words written				
a. Correctly counts the number of words written				
Scoring for words spelled correctly				
a. Misspellings are correctly underlined in red				
b. Correctly counts the number of words spelled correctly (regardless of context)				
Scoring for CWS				
a. Blue upper carets are used to indicate CWS				
b. Red lower carets are used to indicate incorrect word sequences				
c. CWS are counted accurately				
d. Incorrect word sequences are counted accurately				

Part III. Documenting Assessment Outcomes. Inspect CBM graphs.

	Yes 1	No 0	N/A	Observation notes
Graph setup				
a. Dates are correctly labeled on *X*-axis				
b. Name of measure and scoring method is correctly labeled on *Y*-axis				
c. Data points are correctly plotted				
d. A vertical line is drawn to separate baseline data from progress data				
Goal line				
a. Long-range goal is correctly calculated				
b. A goal line is drawn from baseline to the long-range goal				

AIRS—Decision-Making

Implementer:	Observer/rater:
Student:	Date:

Decision-Making. Inspect the implementer's Decision Log(s) and compare with student graphs and/or other data provided.

	Yes 1	No 0	N/A	Notes
Use of decision rules				
a. Teacher made a *timely* decision (i.e., 6–8 data points after baseline or after 4–6 data points after initial decision)				
b. Teacher made an *appropriate* decision using the following decision rules: ☐ Keep instruction as-is (trend line is in line with goal line or data are highly variable) ☐ Raise goal (trend line is above goal line) ☐ Change instruction (trend line is below goal line) ☐ Other reasonable rationale (describe in Notes)				
c. Decision is noted on graph: ☐ Goal line is adjusted (if progress exceeds goal) ☐ Vertical line is inserted (if instructional change is made)				
d. Teacher noted a specific type of instructional change				

AIRS—Writing Instruction

Implementer:	Observer/rater:
Date:	
Start time:	End time:

Implementing Writing Instruction. Observe the instruction implementation, complete the checklist to the extent that the components were included, and write detailed notes regarding other components observed.

	Yes 1	No 0	N/A	Observation notes
The objective(s)/learning target and a rationale for why the skill is being taught is provided				
A motivational strategy or systematic reinforcement is in place				
A warm-up activity is implemented, and/or content from previous day is reviewed				
Activity 1 (describe):				
• Implemented for the specified time				
• Sufficient modeling is provided				
• Sufficient guided practice is provided				
• Sufficient reinforcement is provided for correct responses				
• Sufficient independent practice is provided				
Activity 2 (describe):				
• Implemented for the specified time				
• Sufficient modeling is provided				
• Sufficient guided practice is provided				
• Sufficient reinforcement is provided for correct responses				
• Sufficient independent practice is provided				
Activity 3 (describe):				
• Implemented for the specified time				
• Sufficient modeling is provided				
• Sufficient guided practice is provided				
• Sufficient reinforcement is provided for correct responses				
• Sufficient independent practice is provided				
The content is reviewed through a lesson wrap-up				
An extension for the lesson content for that day is provided				

Note. AIRS = *Accuracy of Implementation Rating Scale*; CBM = Curriculum-Based Measurement; CWS = correct word sequences.

Authors' Note

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ORCID iD

Britta Cook Bresina https://orcid.org/0000-0002-2297-1807

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