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Transfer between Reading Comprehension and Word-Problem Solving among Children with Learning Difficulty in Both Domains

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Abstract

Reading comprehension (RC) and word-problem solving (WPS) both involve text processing. Yet, despite evidence that RC text-structure intervention improves RC, transfer to WPS has not been investigated. Similarly, despite evidence that WPS text-structure intervention improves WPS, transfer to RC has not been examined. The purpose of this randomized controlled trial was to assess effects of single-domain text-structure intervention (RC *or* WPS intervention) for simultaneously improving RC *and* WPS. Second-grade children with comorbid learning difficulty across RC and WPS were randomly assigned to 3 conditions: RC text-structure intervention (RC.INT), WPS text-structure intervention (WP.INT), or the standard school program (the control group). Inferential tests for acquisition effects in multilevel models were significant. RC.INT's effect sizes (vs. control) on RC were g = 1.16 and 0.83; WP.INT's ESs (vs. control) on WPS were g = 1.36 and 1.05. Inferential tests for cross-domain transfer effects in multilevel models were also significant. RC.INT's ESs (vs. control) on WPS were g = 0.41 and 0.68; WP.INT's ES (vs. control) on RC were g = 0.91 and 0.54. Children's text-structure knowledge in passages and word problems mediated acquisition and cross-domain transfer effects in multilevel models. Findings suggest that text-structure intervention may help address the complex needs of children with comorbid RC and WPS difficulty.

Keywords

reading comprehension; word problems; word-problem solving; comorbid reading and math

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Reading comprehension (RC), which is required to build content knowledge in and out of school, is a strong predictor of quality of life, financial security, and health (Berkman et al, 2011; National Research Council, 2012). Word-problem solving (WPS), which is involved in almost every strand of the mathematics curriculum from kindergarten through high school, is one of the best school-age predictors of employment and wages (Murnane et al., 2001). Concurrent learning difficulty across RC and WPS is a serious problem. It occurs frequently and is associated with weaker outcomes and weaker response to intervention than when difficulty occurs in just one domain (Fuchs et al., 2013; Fuchs et al., 2004; Willcutt et al., 2013). In keeping with the literature, we refer to concurrent difficulty as *comorbid* *difficulty* and, in this paper, we use the acronym *RC.WPS.D* to indicate *comorbid difficulty across RC and WPS*.

This form of learning difficulty is frequent, severe, and understudied (Fuchs et al., 2019). A small and largely descriptive literature on comorbid reading and mathematics learning difficulty focuses dominantly on lower-order (word-reading and calculation) skill (e.g., Cirino et al., 2015; Powell et al., 2009a; Willcutt et al., 2013). When intervention has been addressed, the central emphasis is whether effects of mathematics intervention differ for children with comorbid word-reading and calculations difficulty versus children with calculations difficulty alone (e.g., Fuchs et al., 2009; Powell et al., 2009b).

Less attention has been allocated to RC.WPS.D. Some studies have considered connections between RC and WPS by viewing each domain as a form of text comprehension. For example, at second grade, the grade at which the present randomized controlled trial (RCT) was conducted, Cho et al. (2022) examined concurrent risk factors associated with RC.WPS.D by considering foundational academic skill (word reading, calculation), behavioral attention, cognition (working memory, processing speed, nonverbal reasoning), and oral language comprehension (vocabulary, listening comprehension). The shared risk factor across RC and WPS was language comprehension. Relatedly, Fuchs et al. (2018) provided evidence in a longitudinal design that start-of-school-year language comprehension predicted year-end RC as well as WPS, when controlling for initial word-reading and calculation skill and multiple cognitive predictors.

Such findings indicate a connection among RC, WPS, and language comprehension. This, in combination with well-established relations between language comprehension and RC (e.g., Catts et al., 2005; Gough & Tunmer, 1986) and between language comprehension and WPS (e.g., Bernardo, 1999; Chow & Ekholm, 2019; Fuchs et al., 2010, 2015; Hornburg et al., 2018; Van der Schoot et al., 2009), suggests that WPS may be conceptualized and perhaps even treated as a form of text comprehension.

We pursued this idea in the present RCT, which assessed the promise of single-domain text-structure intervention (i.e., RC intervention *or* WPS intervention) for improving RC *and* WPS among children with RC.WPS.D. That is, we asked whether RC text-structure intervention transfers to WPS and whether WPS text-structure intervention transfers to RC. Finding cross-domain transfer would strengthen the basis for conceptualizing WPS as a form of text comprehension and provide proof-of-concept evidence for additional research pursuing an intervention approach involving text-structure instruction for this population. Such an approach would help address the scheduling and resource challenges schools face in conducting intervention in two academic domains for the same child. Because reading intervention usually takes priority over math intervention, many children with RC.WPS.D are underserved.

WPS As a Form of Text Processing

Kintsch and Greeno's (1985) model of WPS, which is rooted in theories of discourse processing (van Dijk & Kintsch, 1983), provides the theoretical framework for this study.

The model assumes that word-problem (WP) representations, as with other forms of text, have three components. The first involves constructing a coherent structure to capture the text's essential ideas. The second, the situation model, requires supplementing the text with inferences based on the problem solver's world knowledge, including information about relations among quantities. The problem solver coordinates this knowledge with the third component, knowledge about problem models, to formalize relations among quantities and guide application of solution strategies within schema.

Kintsch and Greeno (1985) posited that this process of building the propositional text structure, inferencing, identifying schema, and applying solution strategies makes strong demands on memory, attentive behavior, reasoning, and language comprehension (see Fuchs et al., 2021 for discussion). For example, consider this WP: *Selena has 4 puppies. She also has 3 kittens. She went to the store today to buy 2 pounds of pet food. How many animals in all does Selena need to feed?* Attending to information presented in sentence 1, the problem solver reasons that the object in this WP may be *puppies*; a relevant quantity may be 4; the actor may be Selena; and Selena's role and the problem schema are to be determined (TBD). These hypotheses are stored in working memory. Attentive behavior and reasoning are similarly invoked to code and then store in working memory propositions in sentence 2 (object = *kittens*; quantity = 3; actor = Selena; Selena's role and the schema = still TBD). With continued attentive behavior and reasoning, the problem solver next processes sentence 3, conjecturing that *pounds* may be this WP's object and adds this to working memory.

With the question (the final sentence), the problem solver resolves conflicting information stored in working memory and finalizes textual representations by relying on vocabulary knowledge. This involves recognizing *animals* as a superordinate category subsuming *puppies* and *kittens* and understanding *in all* as a linguistic signal that the WP schema involves combining quantities. This leads the problem solver to reject *2 pounds* as irrelevant and assign subset roles to *puppies* and *kittens* (Parts 1 and 2) and the unknown quantity to the role of superset (Total). Filling in these slots of the combine schema (Part 1 + Part 2 = Total) triggers a set of strategies to find the missing quantity. Incorrect solutions may occur as a function of text-processing failures involving inadequate attentive behavior, reasoning, working memory, or language knowledge, which undermine mental representations. They may also occur as a function of computational error.

Schema-Based WPS Intervention as a Form of Text Structure Instruction Designed to Address Text-Processing Demands

Schema-based WPS intervention may be conceptualized as a form of text-structure instruction designed to address the cognitive and language demands described in this WPS model. With schema-based WPS intervention, students learn to conceptualize WPs as belonging to WP types (i.e., text types of *problem models* derived via text processing, as in Kintsch & Greeno, 1985). Children learn a WPS-specific strategy for systematically processing text, as they rely on close reading, analytical reasoning, and text-structure vocabulary in conjunction with a WP-type diagram or equation that maps onto the WP type's structure. Beyond facilitating understanding of the WP type, which supports WP-type identification, the WP-type diagram or equation supports attentional and working memory demands. Children use the diagram or WP equation as an organizing framework for processing text and executing a step-by-step solution strategy for solving that WP type. As they read, they place relevant information into the diagram or equation to transform the representation into a number sentence with a missing quantity. They then compute to solve for the missing quantity.

Research by Jitendra and colleagues (e.g., Jitendra et al., 2007; Jitendra & Hoff, 1996), Powell's research team (Powell et al., 2021; Powell et al., 2015), and Fuchs and associates (e.g., Fuchs, Seethaler et al., 2021; L. Fuchs, Fuchs, et al., 2022) provides corroborating evidence for the efficacy of schema-based text-structure intervention for improving WPS at grades 1 – 3. Meta-analytic estimates are $g = 0.81–1.01$ in Myers et al. (2022), who focused on students with learning difficulties, and $g = 1.57$ in Peltier and Vannest (2017), who included the full range of learners. In the present study, we extended the literature by asking whether effects of schema-based WPS intervention transfer to RC (i.e., whether effects transfer to comprehension of passages with the same text structures but without numbers). We located no prior study investigating this question.

Text Structure Intervention on Text without Numbers

At the same time, we extended the RC text-structure intervention literature by assessing whether RC text-structure intervention (conducted on passages without numbers) transfers to WPS. An extant literature supports the efficacy of RC text-structure intervention for improving children's RC (Duke et al., 2011). Three recent meta-analyses investigated the effects of RC text-structure intervention on RC.

Hebert et al. (2016) summarized effects of 45 studies at grades 1–12. The overall mean effect size (ES) was 0.56. Across types of learners, effects were similarly strong at maintenance (ES = 0.57) and on untaught text structures ES = 0.62, with a substantially smaller ES (0.13) but still significant effect on general reading comprehension measures. With 21 studies spanning kindergarten through grade 12, Pyle et al. (2017) reported a mean overall ES of 0.95. Effects were stronger in the elementary (K–5; ES = 1.03) than at higher grades (ES = 0.63). At grades 4–6, Bogaerds-Hazenberg et al. (2020) focused on structure-based summarization training, with or without instruction on naming text types. Across 44 studies, the overall ES was 0.57 on summarization outcomes, with smaller estimates for question answering (0.25), recall (0.37) and knowledge of text structure (0.38). Importantly, however, effects of structure-based summarization were stronger when training included a focus on text-structure identification and naming: ESs on recall and question answering, respectively, were 1.03 and 0.98. This suggests the value of heightening children's knowledge of specific text types.

These meta-analyses support Duke et al.'s (2011) inclusion of text-structure instruction among effective RC instructional practices. Two of the meta-analyses also suggest that text-structure instruction specifically benefits students with learning difficulties. In Hebert et al. (2016), eight studies permitted disaggregating effects for students with or at-risk for disabilities; the mean ES was 0.97 (vs. 0.56 across learner types). Pyle et al. (2017), whose inclusion criterion required disaggregation of effects for students with or at-risk for learning, reading, or language difficulty, reported a mean ES of 1.66 for students with disabilities across 21 studies. Effects were also strong for typical learners (ES = 1.09) and those at-risk for learning disabilities (ES = 0.99).

The Present RCT

Despite a wealth of evidence that RC text-structure intervention improves RC, we identified no study addressing whether effects transfer to WPS. At the same time, schema-based WPS text-structure intervention research has not investigated transfer to RC. The focus of the present RCT was the promise of single-domain text-structure intervention (RC *or* WPS intervention) for simultaneously improving RC *and* WPS among children with RC.WPS.D. This RCT therefore incorporated three arms: RC text-structure intervention, WPS text-structure intervention, and control (maturation and conventional school instruction and intervention). In the remainder of this section, we provide an overview of this study's two text-structure conditions in conjunction with the study's Theory of Change. For a visualization of the Theory of Change, see Figure 1.

As shown, in each intervention condition, children were taught a domain-specific strategy for constructing text-level representations (situation and problem models). The strategy was designed to address demands on working memory, attentive behavior, analytical reasoning, and text-structure vocabulary knowledge (Perfetti et al., 2008; Rapp et al., 2007; Verschaffel & De Corte, 1997; Williams et al., 2016). In line with Kintsch and Greeno (1985), RC text-structure vocabulary spanned both domains, while WPS text-structure vocabulary also included WPS-specific language. This is also consistent with Fuchs et al. (2015), in which language comprehension's predictive relation with RC was entirely direct on RC, but language comprehension's effect on WPS was partially mediated by WPS-specific language.

The two text-structure interventions were designed in parallel fashion and reflected principles of effective practice identified in one or more meta-analysis. This included addressing two text types (Hebert et al., 2016; Pyle et al., 2017; we did not include more than two text types because intervention, in a sample of second graders with RC.WPS.D, lasted only 15 weeks). It also included a writing component supporting active translation and organization of text information within text-type visualizations (Hebert et al., 2016; Bogaerds-Hazenberg et al., 2020) with graphic organizers, diagrams, and equations; and rule-based summarization training, text-structure naming instruction, and individual child practice (Bogaerds-Hazenberg et al.). Although Hebert et al. found no added value for signal words, we included this common element of effective text-structure instruction (Williams et al., 2014, 2016), because language comprehension is a shared risk factor across RC and WPS difficulty (Cho et al., 2022) and because children with comorbid reading and math difficulty experience substantial delays in vocabulary development (Fuchs, Seethaler, et al., 2021).

The RC and WPS text-structure interventions were designed to maximize parallelisms between the processing of text with and without numbers, while preserving the domain-specificity of each text-processing strategy. This advantaged success in the targeted domain.

The text-processing strategy used in RC intervention and the text-processing strategy used in WPS intervention relied on close reading, analytical reasoning, and text-structure vocabulary in conjunction with a domain-specific diagram mapping the text structure. For WPS intervention, we modified a validated version of second-grade WPS schema-based intervention (Fuchs et al., 2022) by refining the diagram, deepening conceptual instruction on the meaning of each text structure, and expanding text-structure vocabulary instruction to increase the authenticity of the WP texts. We then created a parallel version of text-structure intervention specific to RC.

In each text-structure intervention, we also provided a small amount of transfer instruction to teach the meaning of *transfer* and help children understand what transfer means when applying knowledge and skills learned in the context of passages without numbers to WPs (in the RC.INT condition) or applying knowledge and skills learned in the context of WPs to passages without numbers (in the WP.INT condition). As shown in the WPS literature (e.g., Fuchs et al., 2003; 2008), this kind of transfer instruction supports WPS performance on far-transfer WPS outcomes. Yet, prior studies of such transfer instruction have not addressed transfer from WPS text-structure intervention to RC or from RC text-structure intervention to WPS. Note that this meta-cognitive form of transfer instruction did not teach the transfer-domain's text-processing strategy. We elaborate on this point in the discussion.

For RC intervention, we assessed acquisition effects on RC and cross-domain transfer effects to WPS. For WPS intervention, we assessed acquisition effects on WPS and transfer effects to RC. We conceptualized outcomes in terms of proximity to the intervention, with two RC subtests and two WP subtests. In the context of *acquisition learning* (i.e., effects of RC.INT on RC outcomes; effects of WP.INT on WPS outcomes), the subtest more proximal to intervention indexed children's skill in translating text to a problem model because a domain-specific text-structure strategy was taught during intervention. The more distal subtest indexed text comprehension by having children retell the passage in their own words, a traditional measure of text comprehension not addressed during intervention. *Cross-domain transfer* (i.e., effects of RC.INT on WPS outcomes; effects of WP.INT on RC outcomes) was viewed as far transfer, with the same tasks but in the domain not addressed within intervention.

We assessed text-structure knowledge in passages without numbers and in WPs as a mediator of transfer as well as acquisition effects. We expected text-structure mediation to be complete for RC.INT's effects but partial for WP.INT's effects, given demands for math knowledge when solving WPs.

Research Questions and Hypotheses

Thus, this RCT's central research questions (RQs) were as follows. RQ1 and 2 addressed acquisition, a prerequisite to drawing conclusions about cross-domain transfer: RQ1: Does RC text-structure intervention produce stronger RC outcomes compared to control? RQ2: Does WPS text-structure produce stronger WPS outcomes compared to control? RQ3 and 4 addressed cross-domain transfer: RQ3: Does RC text-structure intervention result in stronger WPS outcomes compared to control? RQ4: Does WPS text-structure intervention result in stronger RC outcomes compared to control? RQ5 concerned mediation: Does text-structure knowledge mediate text-structure intervention's acquisition and transfer effects? These five questions provided the basis for this study's central conclusions.

Differences between the two text-structure conditions were not a major research question, because even comparable performance on another condition's acquisition measure exceeds a reasonable threshold for demonstrating transfer. As noted, the primary contrast condition for demonstrating cross-domain transfer instead involved the counterfactual. For completeness-sake and heuristic purposes and to identify directions for future research, however, we included the contrast between the two active conditions in the main effects models (RQ 6): Do acquisition and cross-domain transfer effects (RC.INT vs. WP.INT) differ significantly?

Based on the Theory of Change (see preceding section), the study's central hypotheses were that (a) RC text-structure intervention transfers to WPS (i.e., stronger WP outcome performance for children in RC text-structure intervention condition compared to control); (b) WPS text-structure intervention transfers to RC (i.e., stronger RC outcome performance for children in WPS text-structure intervention condition compared to control); and (c) acquisition effects and cross-domain transfer are mediated by children's text-structure knowledge. The primary contrast condition for demonstrating transfer was the counterfactual (control group), which permits insight into whether children who receive Domain A intervention perform better on Domain B than would be the case if these children had not received Domain A or Domain B intervention.

Inferential tests of parameters in statistical models were used to address RQ1 – RQ6. As conventionally done in most intervention studies, we also (a) descriptively report and discuss ESs to supplement formal statistical modeling with the goal of providing insight into the magnitude of effects and (b) consider other ES contrasts in exploratory fashion to gain insight into productive directions for future research (by convention, we do not test the significance of ES differences, which are descriptive). Further, to help readers contextualize the RC.WPS.D sample's performance (given that outcome measures were researcher-developed), we also describe outcome performance gaps between children with RC.WPS.D and not-at-risk classmates (expressed as ES differences). Here too, analyses were descriptive, meant to deepen insight into potential impact of intervention for the target population (we did not test for the statistical significance of ESs or gaps).

Method

This RCT involves a multi-level parallel assignment design, controlling for dependence at the classroom and school levels and pretest skill. Children were screened to determine study eligibility. Then, random assignment and 15-week treatment delivery occurred at the individual level. In all three conditions, RC.WPS.D children were tested at pretest, two weeks before treatment ended, and posttest.

Participants

We recruited participants and collected data in accord with protocols approved by our university's institutional review board, which is charged with ensuring compliance with ethical and legal standards. To determine the RC.WPS.D sample size, we conducted power analysis using the Monte Carlo facility of M*plus* 7.11 (Muthén & Muthén, 1998–2013), following Muthén and Muthén (2002). To enter the study as a participant with RC.WPS.D, children had to score below the 25th percentile on RC (*Gates–MacGinitie Reading-Comprehension*; Gates; MacGinitie et al., 2002) and on WPS (*Pennies Story Problems*; Jordan & Hanich, 2000), both administered in whole-class testing, and at or above the 10th percentile on at least one subtest of the individually-administered *Wechsler Abbreviated Scales of Intelligence* (WASI; Wechsler, 2011). (This last criterion was applied because the study's interventions were designed to address the needs of children with intellectual ability in the broadly average range, whose instructional needs differ from those with intellectual disability [e.g., Bouck & Satsangi, 2015.)

In a large, diverse, urban and suburban county-wide school district in the southeastern United States, we screened 1526 second-grade children with teacher consent, parental consent, and student-assent, none of whom had, as reported by teachers, any of the following: a scheduling conflict precluding intervention, very limited or no English, developmental disability, a history of excessive school absences, or were participating in a related RCT. Of the 1526 children, 294 met the RC and WPS low-performance criteria. Given the RCT's predetermined goal for number of children to be individually tested, we randomly selected 275 of the 294. Of these, 26 did not meet the WASI criterion. From the remaining 249 children, we randomly selected 221 to meet the RCT's recruitment goal.

These 221 children entered the RCT and were randomly assigned at the individual level to RC intervention (RC.INT; $n = 74$), WP intervention (WP.INT; $n = 74$), or control (CON; $n = 73$). During their year of participation, 11 moved outside the school district; two were excluded by classroom teachers due to behavior problems; and one developed a scheduling conflict. Thus, 70 in RC.INT, 67 in WP.INT, and 70 in CON completed the study.

To contextualize RC.WPS.D children's performance, we administered measures (except the mediation tasks, due to project resources) to a sample of not-at-risk classmates. We identified classmates by randomly sampling 110 children from the screening pool who scored *above* the cut-point on the RC and WPS screeners and *at or above* 80 on both WASI subtests. During their year of participation, four classmates moved to schools outside the school district (final sample of 106). See Table 1 for demographics and screening data for classmates and for the sample of children with RC.WPS.D by study condition. We draw readers' attention to two variables in Table 1. First, approximately 45% of the sample of children with RC.WPS.D received English learner services. Second, as reflected in RC and WPS screening scores, this study's comorbid sample's difficulty with RC and WPS was severe. We return to these points in the discussion.

Measures

In this section, we describe screening, pretest covariate, mediator, and outcome measures. Measures were administered in the same timeframe for children in all three study conditions and for classmates. Screening measures were administered during the study's screening phase (see Participants section). Pretest covariates were administered after screening but before delivery of study interventions began. The mediator measure was administered in Week 13 of the 15-week intervention period, prior to the end of intervention to preserve temporal precedence with respect to outcome assessment. Outcome measures were administered after intervention ended.

Screening Measures: *Pennies Story Problems* (Jordan & Hanich, 2000) comprises 14 word problems representing combine, compare, or change schema, each with a scenario involving pennies. Problems require sums and minuends to 12 for solution. The tester reads each word problem aloud; children have 30 s to construct an answer and can ask for rereading(s) as needed. The score is the number of correct numerical answers. Sample-based α was .86. *Gates* (Level 2, Form S; MacGinitie et al., 2002) includes 11 narrative or informational passages each with four paragraphs (except the first, 3-sentence passage). Three pictures are shown next to each passage; children select the picture best representing the text. They have 35 min to read and select pictures. Alternate form reliability is .74 – .92. Sample-based α was .82.

WASI (Wechsler, 2011) is a measure of general cognitive ability, comprising *Vocabulary* and *Matrix Reasoning* subtests. *Vocabulary* assesses expressive vocabulary, verbal knowledge, memory, learning ability, and crystallized and general intelligence. Children identify pictures and define words. *Matrix Reasoning* measures nonverbal fluid reasoning and general intelligence. Children complete matrices with missing pieces. Sample-based α were .81 and .84, respectively.

Pretest Covariate Measures: Pretest covariate measures were as follows. With *Test of Word Reading Efficiency - 2* – Sight-Word Efficiency (SWE; Torgesen et al., 2012), children have 45 s to read words of increasing difficulty. Sample-based α was .84. With *Arithmetic* (Fuchs et al., 2003), children have 1 min to answer 25 problems on each of four subtests: *Addition with Sums 0 – 12*, *Addition with Sums 5 – 18* (sums 5 to 18); *Subtraction with Minuends 0 – 12*; and *Subtraction with Minuends 5 – 18*. The score is the total number of correct answers across subtests. Sample-based α was .86.

Mediator Measure: The mediator measure was an experimental task indexing text-structure knowledge in WPs (TKWP) and passages (TKPA) (see Supplemental File Figure 1; SFF1). As children follow along on a copy, testers read aloud three cause-effect passages, three compare-contrast passages, three cause-effect WPs, and three compare-contrast WPs, presented in interleaved fashion (not blocked by domain or text type). Children categorize text as compare-contrast, cause-effect, or neither and underline text-type language (words or phrases that communicate that text-type's structure). For each item, children earn one point for correctly categorizing text type and one point for underlining one or more text-type words or phrases without underlining other words. Sample-based α was .78 for TKWP and .80 for TKPA.

Outcome Measures: The RCT's RC and WPS outcome measures were experimental tasks, with one subtest in each domain aligned with but not used during intervention and the other subtest more distal from intervention. To ensure all children, regardless of study condition, understand the task, testers read a sample passage aloud; then demonstrate their solution strategy and retelling. The RC task relies on four passages. Two describe cause-effect events, with varied cause-effect vocabulary. One passage is more complex (i.e., a longer sequence of actions with more elaborative explanations for those actions). The more complex passage is narrative and contains no irrelevant information; the less complex passage is informational and contains irrelevant information. Two passages involve compare-contrast text, with varied compare-contrast vocabulary. One passage is more complex, describing five features of objects or people being compared (three features are commonalities; two are distinctions); the simpler passage describes three features (two commonalities; one distinction). The more complex passage is narrative and contains no irrelevant information; the less complex passage is informational and contains irrelevant information.

Testers read each passage aloud while the child reads from a copy, with one re-reading if requested. In Subtest 1, *RC Notes*, the more proximal acquisition RC outcome indexing children's skill in translating text to the problem model, children write notes to capture and organize the passage's important information. In Subtest 2, *RC Retell*, the more distal acquisition RC outcome measure indexing text comprehension, testers cover the passage and notes, and children retell the passage using their own words. When indexing cross-domain transfer, all four subtests represented far transfer. If a child pauses for 5 s, testers provide a prompt to add information; after the second 5 s pause or when 2 min elapse, the retell ends.

Audiotapes of RC retells were transcribed. Scorers (graduate students trained to a scoring criterion of 100% by Ph.D. research staff) applied a rubric to RC Notes and RC Retell. In each, they awarded points for identifying text type, use of text-type vocabulary, main ideas, supporting evidence, organization, passage gist, and the absence of irrelevant information. The maximum possible score for RC Notes and RC Retells, respectively, was 74 and 81). Scorers were trained in two 3-hour sessions to .95 agreement. Actual interscorer agreement was 96%. Sample-based α was .82. In pilot work, the correlation with Gates for each subtest exceeded .60.

The WPS experimental task includes 12 problems, six cause-effect and six compare-contrast. Four require addition and eight require subtraction; six include irrelevant information; three provide relevant information in a chart; six place the missing quantity in the final slot of the WP-type number sentence and six in the first or second slot (see WP.INT description for WP-type number sentences). Testers read each problem aloud while children read from a copy, with one re-reading if requested. In Subtest 1, *WP Solutions* is the more proximal acquisition WP outcome, indexing children's skill in translating text to the problem model. In WPS, this poses mathematical demands and involves calculation, thereby representing WP Solutions as demanded on school tasks. Children have up to 90 s to solve each WP, scored for correct math (1 point) and label (1 point) to reflect understanding of the problem's theme and to transform the numerical solution into a meaningful answer. The maximum possible WPS Solutions score was 24.

Subtest 2, *WP Retell*, the more distal acquisition WP outcome indexing text comprehension, relies on 4 of the 12 WPs. Immediately after the child completes the solution on each of these four WPs, testers cover the problem and work; then, children retell the problem and its solution in their own words. When indexing cross-domain transfer, all four subtests represented far transfer. When a child pauses for 5 s, testers deliver a prompt for more information; after the second 5 s pause or when 90 s elapse, the retell for that WP ends.

Audiotapes of WP Retell were transcribed. For each problem, scorers (graduate students trained to a scoring criterion of 100% by Ph.D. research staff) scored each retell against a rubric, with points awarded for identifying text type, use of text-type vocabulary, main ideas, supporting evidence, organization, passage gist, and the absence of irrelevant information. The maximum possible WP Retell score was 48. Interscorer agreement was 98%. Sample-based α was .86. In pilot work, the correlation with *Mathematics Assessment and Diagnostic Evaluation-Process & Applications* (GMADE; Williams, 2019) for each subtest exceeded .60.

Intervention Methods

RC.INT and WP.INT domain-specific text-processing solution strategies were designed in parallel fashion to require children's engagement in close analytical reading and text-structure language knowledge, in conjunction with a diagram or equation that maps onto the text type's structure. RC.INT focused on text without numerals; WP.INT, on text with numerals, which also posed a question. The approach in both interventions relied on schema instruction to teach cause-effect and compare-contrast text structures. Each intervention also included a minor focus on foundational skills (Unit 1 and 5 min of each lesson in other units) and relied on a pirate theme to encourage child engagement.

WP.INT was based on *Vanderbilt Pirate Math* (Fuchs et al., 2019), which is validated at second grade (Fuchs et al., 2022). Contact the second author for sample materials from this study's special version of *Vanderbilt Pirate Math*, designed to run parallel to RC.INT and facilitate transfer from WPS to RC), and for sample materials for this study's RC.INT (*Pirate Reading*), designed to run parallel with WP.INT and facilitate transfer from RC to WPS. Each of the two intervention conditions includes 45 lessons, organized in five units. Three 30-minute lessons are conducted per week for 15 weeks. In this RCT, each intervention was delivered 1:1.

(Note that consistent a multi-tier system of supports or responsiveness-to-intervention prevention system, the study's interventions and the interventions schools provided to control group children [see below] were supplemental to the classroom's instructional program; were provided during the school day; and were considered part of the general education framework, not a specialized form of instruction. Also, children in all three conditions received all of most of the core classroom instructional program.)

Intervention Units: In RC.INT and WP.INT, five units are structured in parallel fashion. *Unit 1* (3 weeks) addresses foundational skills. In RC.INT, this includes symbolic knowledge (e.g., letters, punctuation), word reading, sentence writing, and vocabulary associated with RC.INT's two text types. In WP.INT, foundational skills include symbolic knowledge (e.g., addition sign, equal sign), counting strategies to add and subtract, 2-digit computation, strategies for finding missing quantities in the first or second slot of addition and subtraction number sentences, graphs and charts, and vocabulary associated with WP.INT's two text types.

The remaining units focus on text-structure intervention, with text that gradually increases in complexity (e.g., more irrelevant information, more sentences, greater syntactic complexity) within each unit. Unit 2 (3 weeks) focuses on cause-effect text (passages or WPs), describing a start event, change event (with clear cause and effect), and end event. Each text includes cause-effect vocabulary that spans passages and WPs (e.g., *consequently*, *as a result*). WPs also include WPS-specific language (e.g., *then … more*, *found*). Children are taught to understand and use language for generating hypotheses about the text type and to interrogate hypotheses with close reading and systematic strategies for (dis)confirming the text type and building a meaningful, organized representation of the text.

The domain-specific cause-effect text-type strategy is as follows. RC.INT children rely on a domain-specific diagram representing cause-effect passage structure. While reading, they underline or circle the cause and effect constituting the change; cross out irrelevant information; and use the cause-effect diagram to generate notes that capture the text's cause-effect structure and content. (See SFF 2 and 4 for the RC.INT cause-effect diagram and sample student work.) Finally, with notes and passage covered, children use summarization guidelines to retell the passage in their own words, expressing commonalities and differences and excluding irrelevant details. In both conditions and for both text-types, the diagram is gradually faded.

WP.INT children rely on a domain-specific cause-effect diagram and a WP-type number sentence (ST + C = E or ST − C = E; Start amount plus or minus the Change amount equals the End amount) to represent cause-effect structure. (Note that because missing quantities occur in any slot of number sentences, WP text type does not determine arithmetic operation.) While reading, they circle start, change, and end quantities; cross out irrelevant numbers; underline the word indicating what the WP question is asking about; replace letters in the WP-type number sentence with numerals to generate a math number sentence; use a blank to represent the missing quantity; solve for the missing quantity; and write the numerical answer with a label to answer the WP's question. (See SFF 4 and 5 for the WP.INT cause-effect diagram and sample student work.) Finally, with WP and work covered, they use summarization guidelines to retell the WP in their own words, including the solution and excluding irrelevant details.

Unit 3 (four weeks) focuses on compare-contrast text (passages or WPs). Each text includes compare-contrast vocabulary that spans passages and WPs (e.g., *both, on the other hand*). WPs also include WP-specific language (e.g., *-er* words; *fewer than*). RC.INT children rely on a domain-specific diagram representing the compare-contrast text structure. While reading, they underline or circle the objects being compared; cross out information irrelevant to the compare-contrast main components; and use the compare-contrast diagram to generate notes that capture the objects' shared and distinguishing features. (See SFF 6 and 7 for RC.INT compare diagram and sample student work. See SFF10 for outline of RC.INT compare strategy, which is analogous to the RC.INT cause-effect strategy.) Finally, with notes and passage covered, they use summarization guidelines to retell the passage.

WP.INT children rely on a domain-specific compare-contrast diagram (capturing the idea that compare-contrast WPs involve the comparison of two quantities: how many units in a bigger quantity overlap with a smaller quantity; how many units make the difference [10 vs. 7: 7 overlaps; 3 constitutes the difference]) and a WP-type number sentence (B – s = D; Bigger amount minus the smaller amount equals Difference amount). While reading, they circle bigger, smaller, and difference quantities; cross out irrelevant numbers; underline the word indicating what the WP question is asking about; replace letters in the WP-type number sentence with numerals to generate a math number sentence; use a blank to represent the missing quantity; solve for the missing number; and write the numerical answer with a label. (See SFF 8 and 9 for WP.INT compare diagram and sample student work; see SFF11 for outline of WP.INT compare strategy.) Finally, with work and WP covered, they use summarization guidelines to retell the WP in their own words, expressing the problem solution, while excluding irrelevant information.

Unit 4 (2 weeks) provides explicit instruction to transfer. This includes teaching the concept of *transfer* as well as parallels and distinctions between passages and WPs for each text structure, while emphasizing common text-structure vocabulary across domains. In the 2-week unit, RC.INT and WP.INT address three cause-effect and three compare-contrast passages and WPs. It is important to note that RC.INT's Unit 4 does not address the WPS cause-effect or compare-contrast domain-specific strategy and does not address WP-specific language (see SFF10). Note that WP.INT's Unit 4 does not address the RC cause-effect or compare-contrast domain-specific strategy (see SFF11). Unit 5 (3 weeks) provides review and practice on nine passages and nine WPs, equally representing text structures, with continued emphasis on parallels and language that span text-type in both domains, along with distinctions.

Intervention Segments: Each intervention session comprises three segments: strategic speeded practice on word reading or arithmetic; the lesson, which introduces or reviews the content just described within units; and independent work on that day's content and previously introduced content.

With strategic, speeded practice ("Meet or Beat Your Score"), children have 60 s to solve arithmetic or read word flash cards (in RC.INT and WP.INT conditions, respectively). In WP.INT, they are taught to "know the answer right off the bat" (retrieve from memory) if confident; otherwise, they use the counting strategies taught in Unit 1. Children produce a correct answer for each problem or word because, as soon as an error occurs, tutors require that they use the taught counting to correct the error. To discourage guessing or carelessness, seconds elapse as children execute the counting strategy as many times as needed to produce the correct answer. In this way, careful but quick responding increases correct responses. In RC.INT, because the activity involves sight words, tutors provide corrective feedback for errors. In RC.INT and WP.INT, children have a chance to meet or beat the first score. The day's higher score is graphed.

Tutors then conduct the lesson addressing the unit's content. In each lesson's final 5-min practice segment, children complete a 2-sided practice set that includes sentence practice and cloze reading passages in RC.INT; addition and subtraction problems and a WP in WP.INT. Tutors correct work and provide elaborated feedback on as many as three incorrect responses to repair misconceptions and the solution strategy.

Tutor Training, Support, and Fidelity: Research staff served as tutors. Almost all were university master's students; none had teaching certification. Each staff member tutored children in both conditions: six children (three in each condition) or two children (one in each condition). In initial workshops, the second author provided an overview of intervention conditions; explained distinctions and commonalities between conditions and methods to ensure children received their randomly assigned condition; and modeled key activities in both conditions and provided practice in those activities, with corrective feedback.

After the workshop but prior to the first actual lesson, tutors completed a fidelity check that covered major intervention components with at least 90% accuracy and then demonstrated at least 90% accuracy implementing lesson components with a project coordinator. To promote fidelity, tutors studied lesson guides but did not read from guides while working with children.

Tutors also attended weekly meetings in which they provided updates on children, discussed learning and behavior challenges, and collaboratively problem solved with the first and second authors. Key information on upcoming topics was then reviewed, and materials were distributed. Every intervention session was audio-recorded. Each week, a project coordinator listened to a randomly selected audio-recording and conducted a live observation of each tutor in each condition to identify difficulties, provide corrective feedback, and address problems.

To index fidelity of implementation, we audio-recorded each intervention session and coded 15% of recordings, randomly selected to ensure comparable representation of intervention conditions, tutors, and intervention week. Agreement between independent coders exceeded 95%. The mean percentage of points addressed was 97.34 (SD = 2.09) in RC.INT and 96.66 (SD = 2.29), not a meaningful difference.

School Instruction

On a questionnaire completed in the spring, classroom teachers reported reading and mathematics instructional time. The English language arts block averaged 467.20 (SD = 116.69) min per week; the focus on RC averaged 227.75 (SD = 140.08) (~30% of reading instruction). The mathematics block averaged 309.35 (SD = 87.86) min per week; the focus on WPS averaged 88.80 (SD = 63.76) (~42% of the math instruction). Schools provided reading intervention to 93% of control group students, averaging 33.39 min per day (SD = 20.64); math intervention to 73% of control group students, averaging 9.66 min per day (SD = 15.53).

Teachers also described text-structure instructional practices. In RC, they focused on cause-effect passages in 33.79% (SD = 25.47) of lessons; on compare-contrast passages, 44.65% (SD = 25.47) of lessons. In terms of supports for enhancing text processing, teachers relied strongly on graphic organizers (71.56% [SD = 24.19] of lessons) and moderately on teaching children to take short notes (48.49% [SD = 40.15]) and underline information (52.52% [SD = 31.12]) when reading, and to retell passages (68.74% [SD = 26.79]). Although they taught children to rely on text-structure language (57.19% [SD = 34.53]), their examples revealed teaching associations between isolated word and text types, a practice unlikely to encourage close, analytical reading.

In WPS instruction, teachers focused on cause-effect passages during 84.44% (*SD* = 21.90) of lessons; on compare-contrast passages, 79.25% (*SD* = 29.00) of lessons. In terms of strategies to support text processing, they relied strongly on teaching children to generate number sentences (88.80% [*SD* = 23.06] of lessons) and moderately on attack strategies (66.17% [*SD* = 38.85]), graphic organizers (40.68% [*SD* = 34.29]), and WP retelling (53.26% [*SD* = 36.91]). They also taught children to label answers (77.52% [*SD* = 31.51]). A nonproductive strategy involved heavy reliance (76.19% [*SD* = 32.73]) on keywords associating isolated words with arithmetic operations, which encourages superficial text processing and frequently produces incorrect responses (Powell & Fuchs, 2018). Another nonproductive strategy was drawing pictures to represent WPs, which is time-consuming and often fails to adequately represent schemas (Powell & Fuchs, 2018).

In both domains, other practices incorporated in RC.INT and WP.INT rooted in effective text-structure intervention were not evident in teacher reports. This included a writing component requiring active translation and organization of text information within text-structure visualizations, rule-based summarization training, and text-structure naming instruction.

Procedure

Screening measures were administered in early September in large groups and individually. Pretest covariate measures were administered in early October individually and in small groups. Intervention began in late October and continued into March. The mediator measure was administered two weeks before intervention ended. Within three weeks of intervention's end, posttesting was conducted individually. In each session, the order of test administration was fixed. Sessions ranged from 30 – 60 min. To participate in intervention, most children (83% in RC.INT; 84% in WP.INT) missed the morning meeting. Among the other 17% in RC.INT, 8% missed part of the math block, 4% part of the reading block, and 5% some content area instruction. Among the other 16% in WP.INT, 6% missed part of the math block, 5% part of the reading block, 3% content area instruction, and 1% non-instructional seatwork.

Testers were trained before each wave of testing and had to demonstrate criterion administration accuracy with senior project staff on each measure before testing. Scoring was completed with study condition masked. All test sessions were audio-recorded; 15% were randomly selected, stratified by tester, and doubled-scored by independent coders to check for accuracy. Agreement exceeded 99%.

Transparency and Openness

This report provides the basis for participant exclusions, describes the approach used to determine sample size, and explains data manipulations and analyses. This report's data are available at (https://doi.org/10.33009/ldbase.1721580775.13b0); the data analysis code is available from the third author; and research materials are available from the second author. This study's design and analysis were not preregistered.

Data Analysis

The study's data structure involved three hierarchical levels of clustering: 207 students nested within 109 classrooms nested within 21 schools. To account for dependence of outcomes within classrooms, we employed multilevel specifications that included classroom-specific random effects; this accounted for covariation among outcomes within-classroom. To account for dependence of outcomes within school, we employed a design-based adjustment to standard errors (Sterba, 2009), which uses a sandwich estimator (Taylor linearization) to account for nonindependence of highest-level units (invoked with the TYPE=COMPLEX and CLUSTER IS commands in M*plus* 8.8; Muthén & Muthén, 1998 – 2024). We chose a design-based correction for school-level nesting while fitting two-level models, instead of fitting three-level models because, for some models, the number of estimated parameters could exceed the number of schools. Two-level models (level 1 = student; level 2 = classroom) were fit in Mplus using full-information robust maximum likelihood estimation (MLR).

Data were missing on the pretest SWE covariate for four students. In order to use MLR to retain all cases under missing-at-random assumptions, covariates were treated as endogenous (rather than exogenous), meaning that the covariate sample means and (co)variances were freely estimated along with the rest of the model parameters of the target fitted model (see Sterba, 2014 for review). Because no constraints were placed on these sample means and (co)variances of covariates, simply estimating them at sample values does not affect results of the target model. For simplicity of visual presentation, they are not included in diagrams of target fitted models.

RQ1 – RQ4 are addressed using the main effects multilevel model specification in Figure 2a, where we assess the conditional main effects of intervention conditions controlling for classroom-mean-centered pretest performance (fit in M*plus* 8.8, Muthén & Muthén, 1998–2024). Note that Figure 2a also includes a random intercept for the outcome, which allowed classroom-specific outcome means to randomly vary across classrooms.

Figure 2a also includes two dummy coding variables. The outcome variable in Figure 2a can take on one of four possibilities mentioned in the notes to Figure 2a (RC Notes, RC Retell, WP Solutions, or WP Retell). Addressing RQ1 involved testing the slope (acquisition effect) of the RC.INT versus CON dummy code, where the outcome in Figure 2a is WP Solutions or WP Retell. Addressing RQ2 involved testing the slope (acquisition effect) of the WP.INT versus CON dummy code, where the outcome in Figure 2a is RC Notes *or* RC Retell. To address RQ3, we tested the slope (transfer effect) of the RC.INT versus CON dummy code, where the outcome is WP Solutions or WP Retell. To address RQ4, we tested the slope (transfer effect) of the WP.INT versus CON dummy code, where the outcome in Figure 2a is RC Notes or RC Retell.

To address RQ5, we tested whether text-structure knowledge in WPs (TKWP) or passages (TKPA) mediated the effect of treatment on the outcome, controlling for group-mean-centered pretest (i.e., covariate measures). Specifically, RQ5 was investigated using the multilevel mediation specification in Figure 2b, which now includes a random intercept for both the mediator and the outcome. In the conventional X→M→Y mediation pathway, the *X-variable* corresponds in the Figure 2b mediation model to a given dummy coding for treatment (WP.INT vs. CON *or* RC.INT vs. CON); the *M-variable* labeled "mediator" in the Figure 2b mediation model is TTP-Pass *or* TTP-WPs (see Figure 2b notes); and the *Y-variable* outcome in Figure 2b is RC Notes, RC Retell, WP Solutions, *or* WP Retell (see Figure 2b notes). With two possible *X*-variables, two possible *M*-variables, and four possible *Y*-variables, we use the specification in Figure 2b to test 16 multilevel mediations.

In Figure 2b, for a given mediation pathway, the *a-path* is the effect of a given treatment contrast on the mediator, and the *b-path* is the effect of the mediator on the outcome. The *direct effect* is the effect of that same treatment contrast on the outcome, controlling for the mediator. The *indirect effect* (mediation effect; i.e., *a*-path × *b*-path) is tested for significance by investigating whether 0 lies within the indirect effect's Monte Carlo 95% confidence interval (Preacher & Selig, 2012) using the utility at https://quantpsy.org/medmc/medmc.htm (this Monte Carlo technique is more computationally efficient than constructing bootstrapped confidence intervals [CIs]). Each Monte Carlo CI constructed in this manner provides the 2.5th and 97.5th percentiles of the sampling distribution of the indirect effect, simulated using parameter estimates from each of the 16 versions of the Figure 2b multilevel mediation model.

To address RQ6, which was of secondary interest, we again used the Figure 2a multilevel model, but this time we assessed the mean difference between WPS versus RC.INT on each outcome. We did so by testing the difference *between the slopes* of the two dummy coding variables in Figure 2a for each outcome (see notes Figure 2a) using the Model Constraint command in M*plus*.

Results

In the sample of students with RC.WPS.D, intra-class correlations ranged from .01 to .03 across outcomes at the classroom level and from .001 to .10 at the school level. See Table 1 for means and *SD*s on covariate, mediator, and outcome measures for children with RC.WPS.D by study condition and on covariate and outcome measures for classmates.

Main Effects Models: RQ1 and 2 (Acquisition) and RQ3 and 4 (Cross-Domain Transfer)

Table 2 provides results of multilevel main effects models (Figure 2a) used to address RQ1 – RQ4. Table 2 includes a column labeled *Research Question*, which identifies which significance test of which slope is used to answer which research question (RQ1 – RQ4). Table 2 also provides a column labeled *Interpretation*, which clarifies which tested slopes are interpreted as acquisition versus cross-domain transfer effects.

Results of multilevel main effects models indicated significant positive acquisition effects (RQ1 and RQ2). With respect to RC.INT's acquisition effects on RC outcomes (RQ1), see the significant effect in Table 2 on the proximal acquisition RC Notes outcome (first section; mean difference, RC.INT-CON, $p < .001$) and on the more distal RC Retell outcome (second section; mean difference, RC.INT-CON, $p < .001$). Likewise, in terms of WP.INT's acquisition effects on WPS (RQ2), see the significant effect in Table 2 on the proximal acquisition WP Solutions outcome (third section; mean difference, WP.INT-CON, $p < .001$) and the more distal WP Retell outcome (fourth section; mean difference, WP.INT-CON, p < .001).

Results of the multilevel main effects models also indicate positive cross-domain (far) transfer effects (RQ3 and RQ4). With respect to RC.INT's cross-domain transfer to WP outcomes (RQ3), see the significant effects in Table 2 on the WP Solutions outcome (third section; mean difference, RC.INT-CON, $p = .001$) and on the WP Retell outcome (fourth section; mean difference, RC.INT-CON, $p < .001$). Likewise, in terms of WP.INT's cross-domain transfer (far) to RC outcomes (RQ 4), see the significant effect in Table 2 on the RC Notes outcome (first section; mean difference, WP.INT-CON, $p < .001$) and the WP Retell outcome (second section; mean difference, WP.INT-CON, $p = .001$).

Mediation Models: RQ 5

Results of the Figure 2b mediation models, shown in Table 3, indicate that text-structure knowledge in WPs and passages mediated all the direct effects just discussed for RC and WPS outcomes (RQ 5). That is, each of the 16 indirect (mediation) effects tested was statistically significantly different from 0 (shown in bold). For each of these 16 analyses, Table 3 provides the estimated indirect (mediation) along with its 95% confidence interval, as well as the *a*-path, *b*-path, and direct effect estimate and standard error.

To guide readers, we explain the first two mediation analyses (see top two sections of Table 3). Results for the remaining analyses are read in the same way. In the first section of Table 3, with the outcome *Y=RCN* (RC Notes), mediator *M=TKWP* (text structure knowledge in word problems), and *X=WP.INT*, the *a*-path (effect of WP.INT on text-structure knowledge) was significant ($p = .027$); the *b*-path (effect of text-structure knowledge on the RC Notes outcome) was significant ($p < .001$); the indirect effect (*a*-path × *b*-path) was significant (i.e., the null-hypothesized value of 0 was not inside the 95% CI (0.356 to 6.018); and the direct effect was significant when controlling for the indirect effect ($p < .001$). The total effect can be conceptualized as the sum of the direct and indirect effects (12.123). Because the direct effect was significant when controlling for the mediator, this mediation may be described as partial (rather than *complete*). Mediation was partial for all eight mediation tests when *X=WP.INT*.

In the second section of Table 3, with the outcome *Y=RCN* (RC Notes), mediator *M=TKWP* (text structure knowledge in word problems), and *X=RC.INT*, the *a*-path (effect of RC.INT on text-structure knowledge) was significant ($p < .001$); the *b*-path (effect of text-structure knowledge on the RC Notes outcome) was significant ($p < .001$); the indirect effect (*a*-path × *b*-path) was significant (i.e., the null-hypothesized value of 0 was not inside the 95% CI: (9.636 to 20.687); and the direct effect was not significant when controlling for the indirect effect ($p = .502$). The total effect is 16.876. Because the direct effect was no longer significant when controlling for the mediator, this mediation may be described as *complete* (rather than *partial*). Mediation was complete for seven of the eight mediation tests when *X=RC.INT*.

Summary of Inferential Multilevel Models Testing This Study's Main Three Hypotheses

Inferential multilevel models supported this study's main three hypotheses. Significant acquisition effect and cross-domain transfer effects (when fitting Figure 2a multilevel models; Table 2) supported the study's hypotheses concerning acquisition and cross-domain transfer effects. Significant indirect effects (when fitting Figure 2b multilevel mediation models; Table 3) supported the hypothesis that text-structure knowledge mediates cross-domain transfer and acquisition effects.

Differences between Acquisition and Cross-Domain Transfer Effects: RQ6

Differences between the two text-structure conditions (RQ6), not a major research focus in the present study, were also tested within the multilevel main effects models (Table 2) to provide insights into future research. Results are labeled RQ6 in Table 2. Inspecting all the rows labeled RQ6 in Table 2 indicates the acquisition effects were significantly greater/stronger than cross-domain transfer effects except for the outcome RC Retell.

Descriptive Statistics

See Figure 3 for ESs (bias-corrected *Hedges' g*). For descriptive purposes, in Table 4, we also provide post-intervention performance gaps (mean score for that study condition minus mean score for classmates, divided by the classmate *SD*) by study condition. Bold signifies an acquisition measure for that condition; italics, a cross-domain transfer measure. Negative gaps describe stronger performance for classmates over RC.WPS.D children in that condition; the positive gap describes stronger performance for RC.WPS.D children than classmates. We descriptively interpret ESs and performance gaps in the discussion to provide insight into the potential strength of these text-structure interventions and how these interventions may affect the severity of children's RC and WP difficulties.

Discussion

This RCT's central question was whether single-domain text-structure intervention focused on RC *or* WPS improves performance on RC *and* WPS among second-grade children with RC.WPS.D. This population of children is at-risk for long-term negative consequences in school and beyond. The severity of their comorbid difficulty is reflected in the finding (see Table 1) that our sample, selected for scores below the 25th percentile in each domain, started second grade more than four standard deviations (*SD*s) below the mean of not-at-risk classmates on both of this study's RC and WPS screening measures.

Given the scheduling challenges and resource limitations schools face in conducting intervention in two domains for the same child, many children with RC.WPS.D are inadequately served. This is reflected in the amount of supplemental intervention this study's RC.WPS.D control group children received from schools: 92% of RC.WPS.D children received reading intervention, averaging 35 min per day for those who received it, but only 73% received math intervention, averaging just 10 min per day for those who received it. This suggests the need for interventions that improve performance in the target domain while strengthening performance in the other domain.

Text-structure intervention represents a promising approach for addressing this need. Yet, we located no prior studies assessing transfer from RC text-structure intervention to WPS or from WPS text-structure intervention to RC. For this RCT's WPS intervention, we modified a validated second-grade WPS schema-based intervention program (a) to teach a WPS-specific text-processing strategy based on principles of effective text-structure intervention (Bogaerds-Hazenberg et al., 2020; Herbert et al., 2016; Pyle et al., 2017) and (b) to support transfer to text without numbers (as in Fuchs et al., 2003). In parallel fashion, we created a second-grade RC text-structure intervention using the same principles of text-structure intervention and the same kinds of supports for transfer to text with numbers.

WP.INT did not, however, teach a RC-specific text-processing strategy, and RC.INT did not teach a WPS-specific text-processing strategy. Because children did not receive domain-specific strategy instruction in the transfer domain, they were clearly disadvantaged on transfer outcomes relative to children in the other text-structure intervention condition. Therefore, as specified in this RCT's protocol, transfer in each intervention condition was tested relative to the control group: We asked whether *RC.INT produces stronger WPS outcomes compared to the counterfactual* and *whether WP.INT produces stronger RC outcomes compared to the counterfactual*. Our major conclusions are that single-domain text-structure intervention focused on RC *or* WPS improves performance on RC *and* WPS among second-grade children with RC.WPS.D and that children's text-structure knowledge mediates cross-domain transfer effects.

Text-Structure Intervention's Acquisition Effects (RQ1 and RQ2)

Before addressing transfer, we discuss text-structure intervention's acquisition effects, a prerequisite to considering whether transfer occurred. As expected, children who received RC text-structure intervention significantly outperformed the control group on RC, and children who received WPS text-structure intervention significantly outperformed the control group on WPS. ESs for RC.INT were $g = 1.16$ on RC Notes, indexing translation of text to the problem model, and 0.84 on RC Retell, the measure of text comprehension. ESs for WP.INT were 1.36 on WP Solutions (i.e., translating text to the problem model while posing mathematical demands) and 1.05 on WP Retell, the text comprehension measure.

Large acquisition ESs are in line with meta-analytic findings for RC text-structure intervention on RC outcomes, where mean ESs for children with reading difficulties were 0.97 in Herbert et al. (2016) and 0.99 and 1.66 in Pyle et al. (2017). Similarly, our effects are in line with meta-analytic findings for WPS text-structure intervention on WPS outcomes, where mean ESs for children with mathematics difficulties were 0.81–1.01 in Myers et al. (2022). Results are also consistent with prior wok at second grade: with Fuchs et al. (2022) who addressed WPS text-structure intervention's effects on WPS for children with mathematics difficulties (e.g., $g = 1.51$) and with Williams et al. (2016) who addressed RC text-structure intervention's effects on RC (ESs on passages not used in intervention, $g = 1.75 – 1.79$) but with a sample representing the full range of children in general education classrooms. Present findings extend prior work by demonstrating strong acquisition effects for children with more broad and severe difficulty, specifically children with RC.WPS.D.

We also contribute to this literature by describing post-intervention performance gaps for RC.WPS.D children relative to not-at-risk classmates, as a function of study condition (see Table 4). In thinking about performance gaps, we remind readers that testers modeled the RC.INT and WP.INT solution strategies and retells during post-intervention testing to help all participants (RC.WPS.D children in all three conditions and classmates) understand the outcome tasks. Also, classroom teachers reported relying on features similar to some of this study's text-structure strategies, such that all study participants had some instruction on graphic organizers, taking short notes, underlining text while reading, and retelling passages.

Yet, as revealed in severe post-intervention performance gaps between RC.WPS.D control group children and classmates, the school program failed to meet the needs of children with RC.WPS.D: On RC Notes, RC Retell, WP Solutions, and WP Retell, respectively, the post-intervention performance gap was −1.88 *SD*s, −1.64 *SD*s, −2.18 *SD*s, and −1.31 *SD*s (see Table 4; negative values indicate RC.WPS.D children performed below classmates). This highlights the need for schools to provide intensive intervention.

By contrast, post-intervention performance gaps relative to classmates were substantially less severe on acquisition outcomes in the intervention conditions. In the RC.INT condition, the performance gap with respect to classmates was eliminated on RC Notes, the outcome measure more proximal to RC.INT (+0.08 vs. −1.88 *SD*s in the control group). On RC Retell, the more distal, text comprehension measure, the post-intervention performance gap was −0.64 *SD* (vs. −1.64 in the control group). Similarly, in WP.INT, the post-intervention performance gap was nearly eliminated on WP Solutions, the measure more proximal to WP.INT (−0.08 *SD* vs. −2.18 *SD*s in control). On WP Retell, the more distal text comprehension measure, the gap was −0.58 *SD* (vs. −1.31 in the control group). Readers should keep in mind that performance gap data are descriptive (not subjected to inferential statistical testing) and are meant to help readers interpret inferential main effects model results.

On the basis of the main effects models (Figure 2a; Table 2), we answer RQ1 and RQ2 by concluding that RC text-structure intervention and WPS text-structure intervention improve text-processing and comprehension in the outcome domain aligned with intervention. The performance gaps data suggest that these text-structure interventions may boost RC or WPS performance levels substantially closer to classmates and may improve RC.WPS.D children's access to classroom instruction and their potential to benefit from mainstream instruction. This is of practical importance in serving the needs of this population of learners.

Text-Structure Intervention's Cross-Domain Transfer Effects (RQ3 and RQ4)

More central to the present study's purpose, we asked whether RC.WPS.D children outperform expectations on the transfer domain, as contrasted against the counterfactual: that is, against RC.WPS.D children who did not receive text-structure intervention in either domain. Findings revealed cross-domain transfer, despite that (a) RC.INT children received no instruction beyond what schools provided control group children related to the WPS domain-specific text-processing strategy and (b) WP.INT children received no instruction beyond what schools provided control group children related to the RC domain-specific text-processing strategy.

Each of the four transfer effects was statistically significant. As a descriptive supplement to the inferential tests, note that in the WPS. INT condition, far transfer ESs were similar across measures of text comprehension: In the WPS.INT condition, $g = 0.54$ on RC Retell; in the RC.INT condition, $g = 0.68$ on WP Retell. Yet, in the RC.INT conditions, ESs on measures of text translation to problem models suggest stronger far transfer in the WP.INT condition when RC.INT operated on passages without numbers ($g = 0.91$ on RC Notes) than with numbers ($g = 0.41$ on WP Solutions). We remind readers that this difference in ESs is descriptive (not subjected to inferential statistical testing). One possibility is that a discrepancy favoring transfer in the WP.INT condition on measures involving text translation to problem models may be due to the extra-text demands involved in processing numbers and computing answers on WP Solutions.

Additionally, post-intervention performance gaps with respect to classmates, although descriptive, appear substantially less severe in the intervention conditions than in the control group on three of four transfer outcomes. In the WP.INT condition, the post-intervention performance gap on RC Notes was −0.57 (vs. −1.88 for control) and −1.01 on RC Retell (vs. −1.64 for control). In the RC.INT condition, the post-intervention performance gap on WP Retell was −0.58 (vs. −1.31). As would be expected, RCT.INT children's post-intervention gap was more severe on WPS Solutions than on the other three outcomes but still considerably less severe in the control group: −1.75 *SD*s (vs. −2.18).

It is notable that all four cross-domain transfer effects were statistically significant, especially in light of this study's sample of children with severe learning difficulties. Children with learning difficulties often fail to recognize novel stimuli as related to tasks on which they have received instruction (Haskell 2001; National Research Council 2000). For example, children with mathematics difficulty who are taught to solve WPs combining two quantities to form a total frequently fail to recognize WPs with three quantities to be combined as requiring a similar problem model and solution strategy (Powell et al., 2009a). Differential transfer difficulty is reflected in prior RCTs in which WP transfer distance (degree of alignment between instructional content and outcome measures) had a more deleterious effect on the performance of students with mathematics difficulties than on students who are average or high achieving (e.g., Fuchs et al., 2003).

Given our focus on children with RC.WPS.D, we designed each text-structure intervention to include a limited amount of transfer instruction, with the goal of sensitizing children to parallels between text structures with and without numbers. But transfer instruction did not teach the transfer domain's text-processing strategy. Present study results provide the basis for concluding that, with a limited focus on transfer, single-domain text-structure intervention focused on RC *or* WPS significantly improves performance in the untaught domain, with moderate to large effects. In line with Kintsch and Greeno (1985), findings also indicate that WPS may be understood as a form of text comprehension and that instruction in one domain, which builds children's understanding of text structure across domains via transfer instruction, represents a promising approach for children with RC.WPS.D and perhaps for other populations.

At the same time, we remind readers that the post-intervention performance gap was 1.75 *SD*s for RC.INT children on WP Solutions, which is an essential competency in the mathematics curriculum and a predictor of adulthood employment and wages (Murnane et al., 2001). To provide direction for addressing this issue, future research might contrast effects of RC text-structure intervention against a version that includes a minor focus on computation. At the same time, on the basis of the main effects models (Figure 2a; Table 2), we answer RQ3 and RQ4 by concluding that text-structure intervention improves cross-domain transfer in children with RC.WP.D.

Text-Structure Knowledge as a Mediator of Transfer and Acquisition Effects (RQ5)

Further supporting the conclusion that cross-domain transfer occurred in this RCT is the RQ5 finding that children's text-structure knowledge mediated transfer effects. In this study, text-structure knowledge was operationalized as categorizing text with and without numbers as compare-contrast, cause-effect, or neither and identifying words or phrases that communicate text-type structure.

In analyses involving RC.INT, each of the eight tests contrasting RC.INT against control was mediated by children's text-structure knowledge (Table 3). Half of these effects involve RC (the acquisition domain) but the other half involve WPS (the transfer domain). At the same time, half of these effects involve mediation via text-knowledge in passages (the acquisition domain) but the other half involve mediation via text-knowledge in word problems (the transfer domain). Significant mediation pathways revealed that (a) RC.INT, with its focus on a domain-specific strategy for processing text without numbers combined with limited transfer instruction, improved children's text-structure knowledge in the acquisition and transfer domains (see *a* paths in Table 3) and (b) stronger text-structure knowledge in each domain was associated with stronger performance on each RC and on each WPS outcome (see *b* paths in Table 3).

For seven of the eight mediation tests involving RC.INT, there was complete mediation by text-structure knowledge: The direct effect was no longer significant when controlling for the indirect effect. The eighth mediation effect involves the effect of RC.INT on RC Notes via children's text knowledge in passages without numbers. Here, the direct effect remained significant when controlling for the indirect effect, such that mediation was partial. This makes sense given strong alignment between the RC Notes outcome and the domain-specific strategy taught during intervention.

Mediation was also significant in each of eight tests involving WP.INT (Table 3). Here, half the effects involve WPS but the other half involve RC. At the same time, half involve mediation via text-knowledge in word problems but the other half involve mediation via text-knowledge in passages without numbers. Significant mediation pathways revealed that (a) WP.INT, with its focus on a domain-specific strategy for processing text with numbers combined with limited transfer instruction, improved children's text-structure knowledge in each domain (*a* paths in Table 3) and (b) improvement in text-structure knowledge in each domain was in turn associated with stronger performance on each RC and each WPS outcome (*b* paths in Table 3).

In contrast to mediation results involving RC.INT, mediation in all eight analyses involving WP.INT was partial: The direct effect remained significant when controlling for the indirect effect. This is in line with Kintsch and colleagues' hypothesis that WPS relies on a combination of text processing and mathematics problem-solving processes (Cummins, 1991; Cummins et al., 1988; Kintsch & Greeno, 1985; Nathan et al., 1992). More generally, mediation findings further strengthen support for Kintsch and Greeno's (1985) conceptualization of WPS as a form of text comprehension, while suggesting a causal relation between RC and WPS.

Differences between the Two Text-Structure Conditions

Differences between the two text-structure conditions (RQ6) were not of primary interest in the present study and were not prespecified in the study's analytic plan. This is because even comparable performance on another condition's acquisition measure exceeds a reasonable threshold for demonstrating transfer. The primary contrast condition for demonstrating transfer instead involved the counterfactual (i.e., RQ3 and RQ4). This permits insight into whether the post-intervention performance of children who receive Domain A intervention is stronger on Domain B than if these children had not received Domain A or Domain B intervention.

Nevertheless, for heuristic purposes, we consider differences between the two active conditions to identify directions for future research. *In this context, smaller ESs between the active conditions are more suggestive of transfer than larger ESs*. On WP Solutions, which constituted acquisition in the WP.INT condition but transfer in the RC.INT condition, the effect favoring WP.INT over RC.INT was significant and large ($g = 0.94$). This is at least in part due to extra-text-processing demands in WP.INT. By contrast, on WP Retell, the measure of text comprehension, the ES appeared much smaller ($g = 0.39$) although still significant. On RC outcomes, similar ESs of $g = 0.33$ and 0.30 were significant for RC Notes, but not significant for text comprehension (RC Retell).

Given ESs that suggest a more complicated pattern of transfer from RC.INT to WPS outcomes than for WP.INT to RC outcomes, WPS text-structure intervention (where transfer $g = 0.91$ on RC Notes and 0.54 on RC Retell) may represent the more efficient single intervention option for enhancing performance in both domains when scheduling and resources preclude more than one intervention for the same child. Because this difference in ESs is descriptive, With domain-specific training's advantages favor provision of text-structure intervention in both domains when logistics and resources permit. Future research might investigate effects of integrated text-structure intervention, which teaches text-processing strategies specific to both domains. This approach may produce more similarly strong effects in both domains, even as the efficiencies gained in dual-focused intervention permit less-than-double the intervention time.

Study Limitations

Before summarizing conclusions and implications for practice, we note four study limitations. First, each text-structure intervention included a limited focus on transfer. Therefore, conclusions about cross-domain transfer apply only when single-domain text-structure instruction is delivered with instruction designed to sensitize learners to the idea that passages with and without numbers can share common text structures. Transfer effects of text-structure intervention in each domain, when provided with versus without such transfer instruction, is a research question that warrants attention in future research. Given differential transfer difficulty for children with learning difficulties, such studies might be designed to permit disaggregation of effects by learner type.

A second limitation is that the present study did not include a text comprehension measure with the kinds of tasks typically found on commercial achievement tests, specifically comprehension questions. Relatedly, with this study's focus on close analytical reading, conclusions do not pertain to transfer from RC.INT or WP.INT on measures of extra-textual inferential comprehension. Additional studies are required to provide insight on this issue.

The study's third limitation is that it does not provide the basis for determining whether effects were comparable for children who did and did not receive English language support services. Although children with very limited or no English (as reported by teachers) were excluded from this study (see Participants section), 45% of the sample received English language support services. It is possible children with RC and WPS difficulties who receive English language support services differ in important ways from English proficient peers with such difficulties and perhaps respond to this study's text-structure interventions in distinctive ways. This study, however, was not planned or powered to investigate English learner status as a moderator of intervention effects. Future research might investigate this question. Studies might also assess the efficacy of English text-structure interventions that are adapted in strategic ways to meet the needs of English learners.

Finally, we remind readers that the present study's interventions were delivered individually by research staff who, although not certified teachers, were trained and monitored to ensure strong fidelity of implementation. Future studies should test the effectiveness of such interventions when they are delivered under school conditions more representative of multi-tiered prevention systems, with school personnel implementing interventions in small groups.

This Study's Five Major Conclusions

With these caveats in mind, we draw five main conclusions. First, in second-grade children with RC.WPS.D, RC text-structure intervention and WPS text-structure intervention improve text-processing and comprehension in the targeted domain. RC text-structure intervention improves RC processing and comprehension, and WPS text-structure intervention improves WP processing and comprehension.

Second and more central to this RCT's main question, single-domain RC text-structure intervention transfers to WPS text processing and comprehension, while WPS text-structure intervention transfers to RC text processing and comprehension. Third, children's text-structure knowledge in both domains mediates effects of intervention provided in both domains on both outcomes. Our fourth conclusion is that instruction on one domain, which builds understanding that text structure spans both domains, represents a promising approach for children with RC.WPS.D. Finally, and in line with Kintsch and Greeno (1985), we conclude that WPS may be productively viewed as a form of text comprehension, while findings suggest a causal relation between RC and WPS and indicate that learning in one domain contributes to learning in the other domain.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Educational Impact and Implications Statement

For children with difficulty across reading comprehension (RC) and word-problem solving (WPS), RC text-structure intervention transfers to WPS; WPS text-structure intervention transfers to RC; and text-structure knowledge mediates effects. Findings indicate a causal relation between RC and WPS; that learning in one domain contributes to learning in the other; that WPS may be viewed as a form of text comprehension; and that single-focus text-structure intervention is a promising approach for this population.

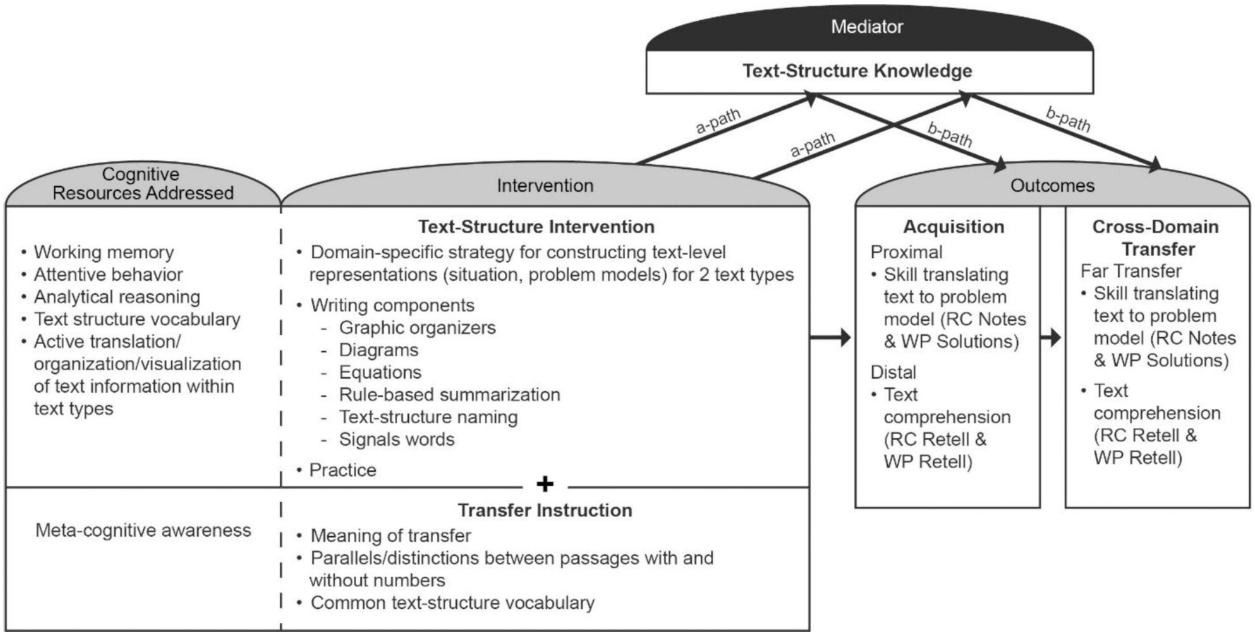
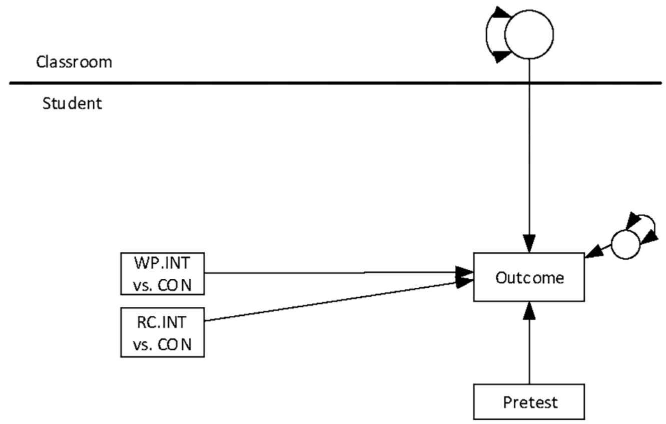


Figure 1. Theory of Change.

Panel A. *Multilevel Main Effects Analysis Diagram*.



Panel B. *Multilevel Mediation Analysis Diagram*.

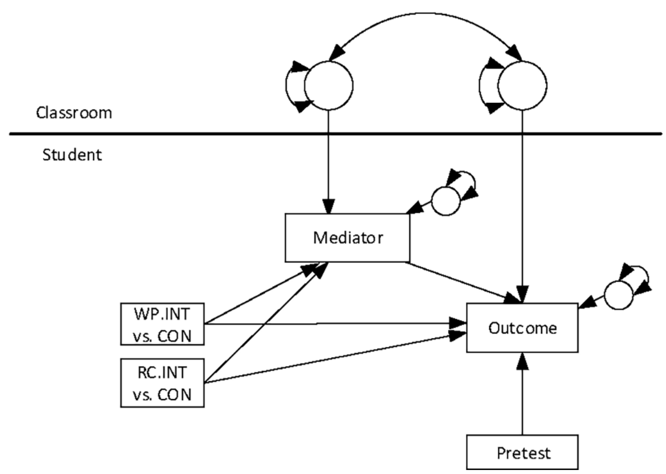


Figure 2. Diagrams of fitted models.

Notes: Outcome is either RC Notes, RC Retell, WPS Solutions, or WPS Retell. Mediator is either TKPA or TKWP. Squares are observed variables. Circles are level-1 residuals or level-2 random intercept residuals. Straight arrows denote regression paths. Curved arrows denote variances. WP.INT is *Pirate Math* second-grade WPS text-structure intervention). RC.INT is *Pirate Reading* second-grade RC text-structure intervention. CON = control group.

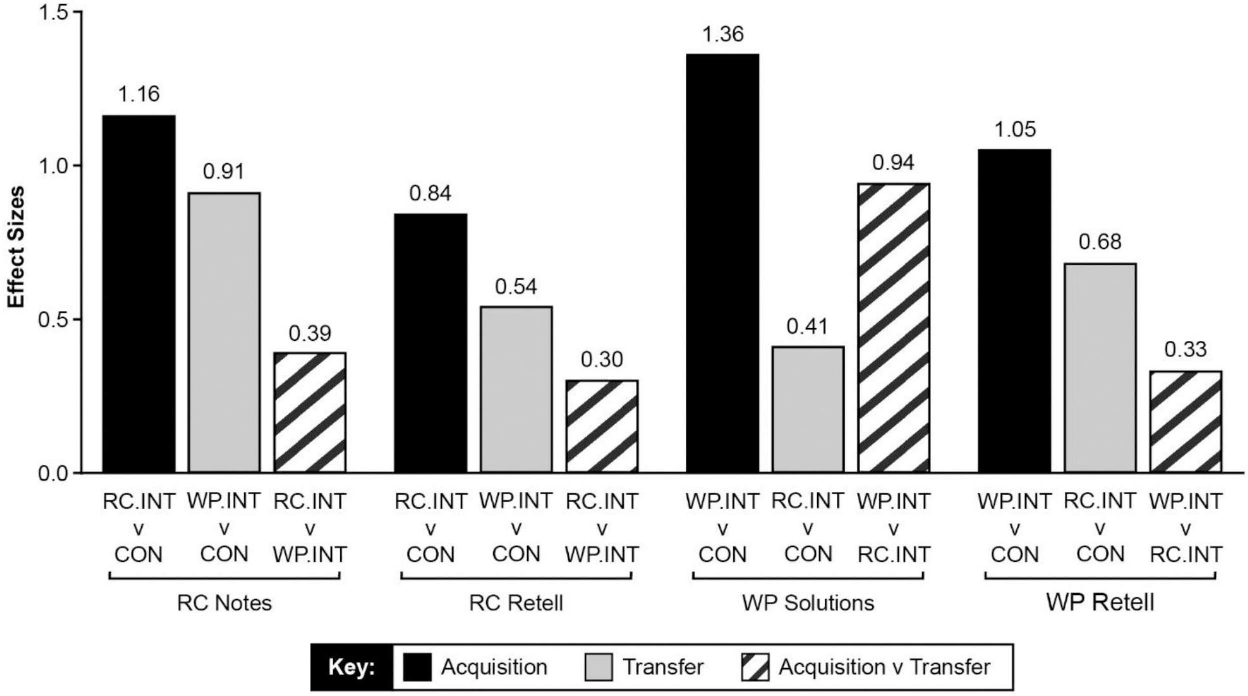


Figure 3. Effect sizes (bias-corrected Hedges' g) for acquisition and transfer outcomes.

Table 1.

Demographics and Screening, Covariate, Mediator, and Outcome Scores by Condition

	Condition											
	Classmates (n=106)			**CON (n=70)**			**WP.INT (n=67)**			**RC.INT (n=70)**		
Variables	**%**	**M**	**(*SD*)**	**%**	**M**	**(*SD*)**	**%**	**M**	**(*SD*)**	**%**	**M**	**(*SD*)**
Demographics												
Sex (female)	54			47			52			64		
English Learner Services	6			47			42			44		
Race/Ethnicity												
Black	27			40			42			36		
Asian	7			3			0			1		
White Non-Hispanic	34			4			10			11		
White Hispanic	20			51			45			44		
Other	12			1			3			7		
Economic Disadvantage	42			61			48			44		
Screening												
Reading Comprehension		30.64	(2.99)		12.83	(4.16)		12.61	(4.01)		11.61	(3.42)
Word Problems		11.09	(2.20)		1.90	(1.07)		1.94	(1.06)		2.01	(1.15)
WASI Vocabulary		53.71	(10.23)		39.17	(8.71)		40.27	(10.05)		36.71	(9.31)
Matrix Reason		50.01	(8.47)		40.44	(6.38)		41.81	(8.05)		41.86	(6.06)
IQ		103.18	(13.26)		82.50	(7.77)		84.69	(10.75)		81.70	(9.18)
Covariate												
Pretest Word ID		55.00	(10.23)		26.76	(15.58)		22.71	(13.67)		20.97	(14.90)
Pretest Arithmetic		29.81	(14.60)		9.64	(6.73)		8.94	(6.77)		8.74	(7.30)
Mediator												
Text-Structure Know Pass		NA			4.67	(1.87)		5.67	(1.93)		9.31	(2.10)
Text-Structure Know WP		NA			4.17	(1.69)		5.09	(1.63)		8.49	(2.06)
Outcome												
RC Notes		29.32	(8.09)		14.11	(8.56)		*24.69*	*(12.14)*		**29.96**	**(16.91)**
Retell		38.62	(9.76)		22.57	(11.86)		*28.73*	*(14.30)*		**32.53**	**(14.94)**
WP Solutions		9.00	(2.63)		3.26	(2.60)		**8.79**	**(5.27)**		*4.40*	*(3.73)*

	Condition											
	Classmates (n=106)			CON (n=70)			WP.INT (n=67)			RC.INT (n=70)		
Variables	**%**	**M**	**(*SD*)**	**%**	**M**	**(*SD*)**	**%**	**M**	**(*SD*)**	**%**	**M**	**(*SD*)**
Retell		22.01	(7.31)		12.40	(7.32)		**21.07**	**(9.40)**		*17.77*	*(9.45)*

Bold signifies acquisition measures in the condition; italics signifies transfer measures in that condition. Reading Comprehension is Gates (MacGinitie et al., 2002); Word Problems is *Pennies Story Problems* (Jordan & Hanich, 2000); WASI is *Wechsler Abbreviated Scales of Intelligence* (Wechsler, 2011); IQ is WASI; Pretest Word ID is *Test of Word Reading Efficiency - 2* – Sight-Word Efficiency (SWE; Torgesen et al., 2012); Pretest Arithmetic is Fuchs et al., 2003); Text-Structure Know Pass is Text-Structure Knowledge in Passages; Text-Structure Know WP is Text-Structure Knowledge in Word Problems; RC Notes is Reading Comprehension Notes; RC Retell is Reading Comprehension Retell; WP Solutions is Word-Problem Solutions; WP Retell is Word-Problem Retell; CON is control; RC.INT is *Pirate Reading* second-grade RC text-structure intervention; and WP.INT is *Pirate Math* second-grade WPS text-structure intervention.

Table 2.

Results for RQ 1,2,3,4, & 6, from Multilevel Main Effects Modeling (in Figure 2a)

		Research Question (RQ#)	Est	SE	*p*-value
Interpretation	Outcome=RC Notes				
	Fixed effects				
	Intercept		13.349	0.956	<.001
Transfer *	Mean difference, WP.INT-CON	RQ4	12.148	1.931	<.001
Acquisition *	Mean difference, RC.INT-CON	RQ1	17.007	2.850	<.001
Acquisit > Trans *	Mean difference, RC.INT-WP.INT	RQ6	4.859	2.188	0.026
	Pretest effect		0.431	0.050	<.001
	Variance Components ‡				
	Student-level residual variance		129.38	21.075	
	Classroom-level intercept variance		18.763	19.964	
Interpretation	Outcome=RC Retell				
	Fixed effects				
	Intercept		21.549	1.243	<.001
Transfer *	Mean difference, WP.INT-CON	RQ4	7.711	2.316	0.001
Acquisition *	Mean difference, RC.INT-CON	RQ1	11.438	2.948	<.001
Acquisit *ns* Transf	Mean difference, RC.INT-WP.INT	RQ6	3.727	2.083	0.074
	Pretest effect		0.457	0.092	<.001
	Variance Components ‡				
	Student-level residual variance		151.524	21.923	
	Classroom-level intercept variance		13.945	12.600	
Interpretation	Outcome=WP Solutions				
Fixed effects					
	Intercept		3.122	0.369	<.001
Acquisition *	Mean difference, WP.INT-CON	RQ2	5.679	0.604	<.001
Transfer *	Mean difference, RC.INT-CON	RQ3	1.4	0.415	0.001
Acquisit > Transf *	Mean difference, RC.INT-WP.INT	RQ6	−4.279	0.531	<.001
	Pretest effect		0.173	0.054	0.001
	Variance Components ‡				
	Student-level residual variance		11.799	1.386	
	Classroom-level intercept variance		3.407	1.295	
Interpretation	Outcome=WPS Retell				
	Fixed effects				
	Intercept		11.923	1.063	<.001
Acquisition *	Mean difference, WP.INT-CON	RQ2	9.234	1.388	<.001

		Research Question (RQ#)	Est	SE	***p*-value**
Transfer *	Mean difference, RC.INT-CON	RQ3	5.937	1.466	<.001
Acquisit > Transf *	Mean difference, RC.INT-WP.INT	RQ6	−3.297	1.183	0.005
	Pretest effect		0.576	0.106	<.001
	Variance Components ǂ				
	Student-level residual variance		50.373	7.720	
	Classroom-level intercept variance		18.564	7.021	

Notes. RQ=Research Question.

* =p *<.05.*

ǂ *z*-tests of variance components are conservative and should be viewed as approximate. *ns*=nonsignificant. RC Notes is Reading Comprehension Notes; RC Retell is Reading Comprehension Retell; WP Solutions is Word-Problem Solutions; WP Retell is Word-Problem Retell; CON is control; RC.INT is *Pirate Reading* second-grade RC text-structure intervention; WP.INT is *Pirate Math* second-grade WPS text-structure intervention; CON is control group. See Figure 3 for effect sizes (bias-corrected *Hedges g*).

Table 3.

Results for RQ5 from Multilevel Mediation Modeling (in Figure 2b)

Model	Path	Estimate	SE	*p*-value
y=RCN m=tkwp x=WP.INT	*a*-path	0.896	0.405	0.027
	b-path	3.454	0.551	<.001
	direct effect	9.028	1.751	<.001
	indirect effect	**3.095**	**95%CI=(0.356, 6.018)**	
y=RCN m=tkwp x=RC.INT	*a*-path	4.304	0.428	<.001
	b-path	3.454	0.551	<.001
	direct effect	2.009	2.992	0.502
	indirect effect	**14.867**	**95%CI=(9.636, 20.687)**	
y=RCN m=tkpa x=WP.INT	*a*-path	1.000	0.379	0.008
	b-path	1.984	0.554	<.001
	direct effect	10.035	1.760	<.001
	indirect effect	**1.985**	**95%CI=(0.287, 4.876)**	
y=RCN m=tkpa x=RC.INT	*a*-path	4.616	0.316	<.001
	b-path	1.984	0.554	<.001
	direct effect	7.724	2.277	0.001
	indirect effect	**9.161**	**95%CI=(3.784, 15.451)**	
y=RCR m=tkwp x=WP.INT	*a*-path	0.904	0.404	0.025
	b-path	2.040	0.716	0.004
	direct effect	5.765	2.328	0.013
	indirect effect	**1.843**	**95%CI=(0.154, 3.993)**	
y=RCR m=tkwp x=RC.INT	*a*-path	4.297	0.426	<.001
	b-path	2.040	0.716	0.004
	direct effect	2.587	4.749	0.586
	indirect effect	**8.766**	**95%CI=(2.645, 15.449)**	
y=RCR m=tkpa x=WP.INT	*a*-path	0.992	0.377	0.009
	b-path	1.341	0.444	0.003
	direct effect	6.280	2.184	0.004
	indirect effect	**1.330**	**95%CI=(0.207, 2.990)**	
y=RCR m=tkpa x=RC.INT	*a*-path	4.628	0.298	<.001
	b-path	1.341	0.444	0.003
	direct effect	5.070	3.365	0.132
	indirect effect	**6.204**	**95%CI=(2.157, 10.445)**	
y=WPS m=tkwp x=WP.INT	*a*-path	0.902	0.395	0.022
	b-path	0.547	0.186	0.003
	direct effect	5.237	0.526	<.001

Model	Path	Estimate	SE	*p*-value
	indirect effect	**0.494**	**95%CI=(0.042, 1.160)**	
y=WPS m=tkwp x=RC.INT	*a*-path	4.302	0.421	<.001
	b-path	0.547	0.186	0.003
	direct effect	−0.955	0.728	0.190
	indirect effect	**2.355**	**95% CI=(0.744, 4.196)**	
y=WPS m=tkpa x=WP.INT	*a*-path	1.003	0.372	0.007
	b-path	0.353	0.163	0.030
	direct effect	5.338	0.547	<.001
	indirect effect	**0.354**	**95%CI=(0.010, 1.061)**	
y=WPS m=tkpa x=RC.INT	*a*-path	4.635	0.305	<.001
	b-path	0.353	0.163	0.030
	direct effect	−0.235	0.630	0.710
	indirect effect	**1.637**	**95%CI=(0.144, 3.288)**	
y=WPR m=tkwp x=WP.INT	*a*-path	0.918	0.394	0.020
	b-path	1.183	0.442	0.007
	direct effect	8.273	1.445	<.001
	indirect effect	**1.087**	**95%CI=(0.089, 2.480)**	
y=WPR m=tkwp x=RC.INT	*a*-path	4.310	0.425	<.001
	b-path	1.183	0.442	0.007
	direct effect	0.841	2.445	0.731
	indirect effect	**5.100**	**95% CI=(1.286, 9.364)**	
y=WPR m=tkpa x=WP.INT	*a*-path	1.048	0.364	0.004
	b-path	0.984	0.267	<.001
	direct effect	8.233	1.370	<.001
	indirect effect	**1.032**	**95%CI=(0.234, 2.170)**	
y=WPR m=tkpa x=RC.INT	*a*-path	4.654	0.298	<.001
	b-path	0.984	0.267	<.001
	direct effect	1.350	1.889	0.475
	indirect effect	**4.581**	**95%CI=(2.123, 7.131)**	

y = outcome: RCR is Reading Comprehension Retell; RCN is RC Notes; WPS is Word-Problem Solutions; WPR is Word-Problem Retell. M = mediator; tkwp is Text-Structure Knowledge in Word Problems; tkpa is Text-Structure Knowledge in Passages; x = intervention: RC.INT is *Pirate Reading* second-grade RC text-structure intervention; WP.INT is *Pirate Math* second-grade WPS text-structure intervention.

Table 4.

Post-Intervention Performance Gaps between RC.WPS.D Children versus Classmates by Study Condition

	CON (n=70)	WP.INT (n=67)	RC.INT (n=70)
Outcome Measure	**ES**	**ES**	**ES**
RC Notes	−1.88	*−.057*	**+0.08**
RC Retell	−1.64	*−1.01*	**−0.64**
WP Solutions	−2.18	**−0.08**	*−1.75*
WP Retell	−1.31	**−0.58**	*−0.58*

Gap = (mean score for RC.WPS.D children in that condition minus mean score for classmates) divided by the classmates' *SD*. Bold signifies acquisition measure in that condition. Italics signify transfer measure in that condition. Negative gaps indicate classmates' performance was stronger. The positive gap indicates RC.WPS.D children's performance was stronger. RC Notes is Reading Comprehension Notes; RC Retell is Reading Comprehension Retell; WP Solutions is Word-Problem Solutions; WP Retell is Word-Problem Retell; CON is control; RC.INT is *Pirate Reading* second-grade RC text-structure intervention; and WP.INT is *Pirate Math* second-grade WPS text-structure intervention.