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Effectiveness of Tier I Content-Integrated Literacy Intervention on Early Elementary English Learners' Reading Comprehension and Writing: Evidence from Randomized Controlled Trial

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Abstract

The current study replicated and extended the previous findings of content-integrated literacy intervention focusing on its effectiveness on first- and second-grade English learners' (*N* = 1,314) reading comprehension, writing, vocabulary knowledge, and oral proficiency. Statistically significant findings were replicated on science and social studies vocabulary knowledge (ES = .51 and .53, respectively) and argumentative writing (ES = .27 and .41, respectively). Furthermore, treatment group outperformed control group on reading (ES = .08) and listening comprehension (ES = .14). Vocabulary knowledge and oral proficiency mediated treatment effects on reading comprehension, whereas only oral proficiency mediated effects on writing. Findings replicate main effects on vocabulary knowledge and writing, while also extending previous research by highlighting mechanisms underlying improved reading comprehension and writing.

Keywords: content literacy intervention, English learners, reading comprehension, writing, vocabulary knowledge, English oral proficiency

Effectiveness of Tier 1 Content-Integrated Literacy Intervention on Early Elementary English Learners' Reading Comprehension and Writing: Evidence from Randomized Controlled Trial

Educators, researchers, policymakers, and school administrators alike are increasingly invested in U.S. primary-grade English learners' (ELs') literacy development in English as their new language (August & Shanahan, 2006; Cardenas-Hagan, 2020). Young ELs are often from non-English-speaking households and attend high-poverty urban schools that suffer from inadequate and unequal educational resources. They are often pulled out of English language arts (ELA) or content-area subject classes to receive English-as-a-second-language (ESL) instruction that typically concentrates on the improvement of oral language proficiency primarily (Brisk, 2006). As a result, many ELs who bring diverse cultural and linguistic resources to schools often experience significantly fewer opportunities to build literacy prowess and have less access to rigorous academic content that they must master to ensure their long-term academic success relative to their monolingual English-speaking peers (Callahan, 2005; Hopkins et al., 2015). It is critical to identify effective general classroom (i.e., Tier 1) instruction frameworks and curricular resources that may provide ELs' with equitable access to opportunities to learn and promote their literacy and academic development.

Many early literacy instruction programs have been designed and delivered to foster primary-grade (K-2) ELs' constrained, code-based skills such as alphabetic principle, phonological awareness, and oral reading proficiency (e.g., Denton et al., 2004; Ehri et al., 2007; Gerber et al., 2004; Gunn et al., 2000; McMaster et al., 2008; Vadasy et al., 2010, 2011; Vaughn et al., 2006a; 2006b). However, ELs typically develop adequate constrained or word reading skills at rates similar to their English-speaking monolingual peers (Lesaux et al., 2006), and they are expected to catch up to monolingual peers as they receive all-English instruction (Mancilla-

Martinez & Lesaux, 2011). After the primary grades, ELs' oral language skills (e.g., listening comprehension) and vocabulary knowledge begin to account for more variability in reading comprehension as they read increasingly complex texts (Catts et al., 2005; Garcia & Cain, 2014; Goldenberg, 2020; Language and Reading Research Consortium [LARRC], 2015; Vellutino et al., 2007). Therefore, young ELs' early development of English oral language and vocabulary knowledge play an increasingly critical role in unconstrained, meaning-based skills (e.g., reading comprehension, writing) that continuously develop over time (Paris, 2005; Snow & Kim, 2007).

Additionally, there has been growing recognition of the importance of developing content knowledge in the service of unconstrained literacy skills (Cabell & Hwang, 2021; Cervetti & Wright, 2020). It has long been understood that readers' content knowledge on a particular topic plays a vital role in better understanding a text about the topic. Anderson and Pearson (1984) posit that "poor readers are likely to have gaps in knowledge" (p. 286). What a reader already knows is a determiner of what the readers can comprehend; that is, the less the reader knows, the less the reader can understand a text. This holds true, especially for ELs in a dual-task of learning a new language and content simultaneously. Content knowledge is disproportionately critical for ELs because they may be less familiar with the content of U.S. school textbooks compared to their native-English-speaking monolingual classmates (August & Shanahan, 2006; García, 2000). Grade-level reading comprehension challenges due to ELs' gradually developing English proficiency can be alleviated when they already possess prior knowledge or expertise relevant to a specific topic of a text (Peregoy & Boyle, 2017).

It is well documented that ELs can benefit from effective and well-implemented oral and academic language instruction (e.g., Academic Language Instruction for All Students [ALIAS; Lesaux et al., 2010; 2014], Word Generation [Lawrence et al., 2015]) and content-integrated

literacy instruction (e.g., Directed Language Approach to Science Instruction [DLASI; Brown et al., 2010], Promoting Adolescents' Comprehension of Text [PACT; Vaughn et al., 2009, 2017], Quality English and Science Teaching [QuEST; August et al., 2009]) in improving vocabulary and reading comprehension (see reviews by Hwang et al., 2021; Truckenmiller et al., 2019). However, the research findings are predominantly based on the sample of upper-elementary to secondary grades students, such that little is known about the impact on student outcomes at early elementary levels. Although emerging evidence on the effects of primary-grade content-integrated literacy instruction on a general population shows promise for instructional approaches and delivery features (e.g., Content-Area Literacy Instruction [CALI; Connor et al., 2017], Concept-Oriented Reading Instruction [CORI; Guthrie et al., 2004], In-Depth Expanded Applications of Science [IDEAS; Romance & Vitale, 2001], BLINDED FOR PEER-REVIEW [Authors, 2021a; 2021b]), little evaluation has been undertaken to determine its impact on the EL population. It is critical to undertake this research because there may be opportunity costs in that early-grade content-focused literacy instruction may result in adverse effects on ELs' foundational code-related skills or reading comprehension. On one hand, the instruction may enhance effects by providing children with multiple encounters with the form and meaning of words and thus build high-quality lexical representations (Perfetti, 2007). On the other hand, the instruction may not provide sufficiently robust foundational word reading instruction to build young readers' phonological awareness, word decoding, and fluency.

The current study aimed to examine the impact of a Tier 1 (i.e., core classroom) content-integrated literacy intervention program, called [BLINDED FOR PEER-REVIEW], on first- and second-grade ELs' reading comprehension, argumentative writing, vocabulary knowledge, and English oral proficiency (speaking and listening). The intervention program has been proved to

be effective in improving young children's argumentative writing and vocabulary knowledge regardless of their language status (e.g., Authors, 2021b). The overarching goal of this study was to advance the extant research base by evaluating the extent to which Tier 1 content-integrated literacy instruction improved ELs' reading comprehension, argumentative writing, vocabulary knowledge, and English oral proficiency. Beyond the focus on the main treatment effects, a unique aspect of the present study was to focus on mediation effects on reading comprehension and writing outcomes via vocabulary knowledge and English oral proficiency.

Theoretical Foundation for Content-Integrated Literacy Instruction

Content-integrated literacy instruction can be broadly defined as a pedagogical framework in which reading, writing, and language activities serve as a major vehicle for accessing, developing, and communicating content knowledge, and at the same time, the knowledge-building process and outcomes can provide a context to enhance and advance literacy tools (Hwang et al., 2021; Pearson et al., 2010; Walmsley & Walp, 1990). Although the conceptualization of content-integrated literacy instruction may vary across contexts, its common ground instructional approaches endeavor to capitalize on the content knowledge acquisition and development that play a critical role in improving reading comprehension (e.g., Guthrie et al., 2004; Vaughn et al., 2017, 2022) and writing (e.g., Authors, 2021a; 2021b). Knowledge gained from reading and writing can be enhanced, refined, and augmented through increasingly challenging and complex literacy activities.

The reciprocal views of the knowledge-comprehension relationship are grounded in contemporary cognitive models of reading comprehension (e.g., Graesser et al., 1994; Kendeou & van den Broek, 2005; Kintsch, 1988; Perfetti, 1999; van den Broek et al., 2005). These models describe reading comprehension as the process of constructing coherent mental text

representation and integrating the text content and relevant background knowledge into the reader's mental representation or knowledge system. The mental representation of a text refers to a situation model, in which readers elaborate semantic meanings and relatedness between contiguous sentences found in a text and integrate them with prior knowledge, constructing an enriched knowledge network of semantically meaningful information (Kintsch, 1988; van Dijk & Kintsch, 1983). The process of establishing and preserving a situation model is important because it facilitates a reader's deeper understanding of a text and capacity to learn from text. (Kintsch, 1980).

The development of a situation model may be particularly critical for ELs who learn to read in English as an additional language. When young ELs process texts written in English, they constantly bring knowledge of multiple linguistic and semiotic systems in first and second languages to texts, select meaning-making features, and combine them to construct meaning (García & Wei, 2014). Such metalinguistic abilities serve as strengths for bilingual readers (Bialystok, 2017), enabling them to free up attentional resources for processing texts and use them to compensate for limited linguistic abilities in constructing a situation model during text comprehension. Additionally, previous studies on monolingual students suggest that students with relatively low verbal ability but a higher level of topic knowledge show better text comprehension than their peers with lower verbal ability and knowledge level (e.g., Burgoyne et al., 2009; Fincher-Kiefer et al., 1988; Yekovich et al., 1990). High-knowledge students are more competent in constructing a situation model of a text by retrieving relevant knowledge stored in their long-term memory than low-knowledge students who need to start the model-building process from scratch (Ericsson & Kintsch, 1995; Kurby & Zacks, 2012; Zwaan & Radvansky, 1998). In the case of ELs, English oral ability significantly contributes to reading comprehension

(Snow et al., 1998), yet a strong situation model and knowledge structure may play a complementary role in facilitating text comprehension.

How Might Content-Integrated Literacy Instruction Support English Learners' Reading Comprehension and Writing?

Despite the theoretical justification for the knowledge-comprehension relationships, extant empirical research examining literacy instruction that emphasizes content knowledge-building components has largely been conducted with English-speaking monolingual students and less research has been devoted to young ELs. However, limited research evidence suggests a positive contribution of content knowledge to reading comprehension among second language readers (e.g., Droop & Verhoeven, 1998; Levin & Hause, 1985; Rydland et al., 2012). A remaining important question is how to best target Tier 1 content-area instruction as an opportunity for knowledge building in support of young ELs' reading comprehension and writing. It is important for schools to provide high-quality core or Tier 1 classroom instruction with a solid evidence base that ELs can benefit from (Baker et al., 2014). Although many young ELs can develop and master foundational reading skills such as phonological awareness and word decoding in a relatively short period of time, they need ample opportunities to build sophisticated academic language skills and new challenging content knowledge to be able to comprehend and construct increasingly complex texts loaded with abstract concepts and vocabulary in the context of regular classroom instruction (August & Shanahan, 2006).

Conceptual Model

Figure 1 displays a hypothesized logic model that illustrates how the current Tier 1 content-integrated literacy intervention can yield improved outcomes via the enhancement of mediators. We hypothesized that the multi-component Tier 1 instruction, in which a set of

instructional components act synergistically to create language-rich and collaborative classroom environments, provides ELs with the opportunities to access high-rigor curriculum and to interact with their peers and teachers in deep processing of new content and concepts in authentic learning contexts. Such opportunities promote ELs' deep knowledge of sophisticated, academic words and concepts as well as oral language and listening comprehension that are necessary for understanding and producing written texts. The recent study findings with a general population of students (e.g., Authors, 2021b) confirmed this hypothesis partially in that vocabulary knowledge was a key mechanism accounting for the transfer effects on reading comprehension and writing competencies. In addition to vocabulary knowledge, for ELs, it is further possible that English oral proficiency may play a mediating role in the intervention effects on reading comprehension and writing. That is, content-integrated literacy treatment may positively affect ELs' oral proficiency development, which, in turn, facilitates the ability to understand and write content-rich texts.

Core Instructional Components

The current intervention consisted of the following evidence-based instructional components: (a) the use of conceptually related complex informational texts in a thematic unit in interactive read-aloud activities, (b) domain-specific vocabulary network building, (c) argumentative writing, and (d) research collaboration. This set of components was aligned with the Institute of Education Sciences (IES) What Works Clearinghouse (WWC) Educators' Practice Guide for teaching academic content and literacy to ELs (Baker et al., 2014). This Guide provided four recommendations for educators of ELs as follows: (a) Recommendation 1: provide intensive instruction of academic vocabulary words across several days using various instructional methods; (b) Recommendation 2: incorporate both oral and written English

language instruction into content-area classes; (c) Recommendation 3: provide opportunities for ELs to cultivate their written language skills; and (d) Recommendation 4: provide small-group intervention to ELs experiencing literacy and language difficulties. The following section provides a detailed description of the instructional components and how they are converged with the recommendations.

Thematically and Conceptually Related Complex Informational Texts

We designed the instruction lessons to be organized into a thematic unit in which students were engaged in reading thematically and conceptually related complex informational texts in a science and social studies topic. This instructional approach was considered aligned with the WWC Practice Guide Recommendation 2. The use of content-rich informational texts in primary grades provides a context to build, apply, and communicate world knowledge and areas of expertise as a motivating vehicle for further engagement in reading and writing (Duke, 2000). Reading multiple informational texts that are conceptually connected in the thematic unit can be particularly beneficial to developing greater breadth and depth of conceptual and vocabulary knowledge in a thorough and coherent manner (Author, 2021).

It is important to ensure that ELs have an opportunity to engage in complex texts at an appropriate level of rigor aligned with grade-level expectations. However, informational texts may pose unique challenges associated with reading comprehension for ELs due to text characteristics, including the presence of technical vocabulary, limited background knowledge of a particular topic, and complex text and sentence structure (Martin & Duke, 2011; Williams, 2005). To mitigate these challenges and promote ELs' abilities to acquire content knowledge and informational text comprehension skills, an interactive read-aloud approach was utilized in the current intervention. A large body of research indicates that reading text aloud to children can

facilitate the development of listening and reading comprehension and prior knowledge-building process (Biemiller, 2003; Hickman et al., 2004; Mol et al., 2009). During the interactive read-aloud activities using informational texts, teachers demonstrated visible mental models of the comprehension process and invited students to engage in text-based discussion, which provided an authentic, language-rich context that made informational texts accessible and meaningful to ELs. Engaging in such activities can help ELs gain a deeper understanding of abstract academic words and improve their oral language proficiency.

Vocabulary Network Building

Consistent with the WWC Practice Guide Recommendation 1, the current intervention provided teachers with an opportunity to support students in building domain-specific academic vocabulary knowledge using concept mapping activities. Concept mapping is the visualization process of organizing semantically related vocabulary words to build students' high-quality mental semantic representation of words and learn to retrieve the knowledge from semantic long-term memory (Author, 2021; Perfetti, 2007). Building a cognitive network is the process of adding new words representing a concept to mental lexicon and expanding or deepening existing knowledge by creating linkages in a network structure (Murphy, 2003; Steyvers & Tenenbaum, 2005). As children begin to acquire more challenging disciplinary content, mapping and building mental networks become increasingly more essential in ensuring cognitive accessibility to depth and quality of lexical and conceptual knowledge (Anderson & Freebody, 1981; Brysbaert et al., 2000; Kintsch, 1998). The concept mapping activity may be especially beneficial for ELs who invest an additional cognitive effort in reading in a new language that is not fully developed relative to their monolingual peers. The gradual and cumulative network development may

lessen ELs' cognitive demands while they acquire new language proficiency and academic content knowledge simultaneously.

Argumentative Writing and Research Collaboration

As compared to the two preceding components implemented to build students' content knowledge structure, two additional components were incorporated to promote the opportunity for knowledge application and transfer. The first component was an argumentative writing task, associated with the WWC Practice Guide Recommendation 3, in which students learned to write an argument and provide reasons and textual evidence to support their claim on a science and history topic. In a context of content-focused argumentative writing activities, novice writers learn a self-regulated strategy to apply (Graham & Harris, 2005) and practice to produce an academic text that requires concise and persuasive communication skills in a written form, drawing on various facets of linguistic resource (e.g., vocabulary knowledge, syntactic knowledge), topic knowledge, and text organizational structures (Myhill, 2009; Phillips Galloway & Uccelli, 2015). For young ELs who compose a demanding topic in a second language, the working memory capacity might not be sufficient to consider linguistic and content demands simultaneously. However, multiple writing opportunities, relevant content knowledge, and vocabulary knowledge may release cognitive overload forces during writing (Galbraith & Rijlaarsdam, 1999; McCutchen, 2000), enabling ELs to enhance awareness of key features in the writing process and to achieve higher quality text writing.

The second component was research collaboration to provide students with opportunities to engage in small-group discussions around the unit topics presented in the complex texts. Students worked with their peers to conduct research on the unit topics using authentic texts from newspaper and magazine articles and engaged in critical, collaborative dialogue and writing

tasks with their peers. The goal of the research collaboration activity was for students to build and expand content knowledge of science and social studies and deepen their academic vocabulary networks. This activity was also to create collaborative classroom environments in which ELs had opportunities to engage in challenging academic conversations and task with their peers and improve their oral language skills.

The Current Study

The present study was designed to replicate findings from the previous studies of Tier 1 content-integrated literacy intervention for first- and second-grade students (Authors, 2021a; 2021b) and extend understanding of the effects on the EL population. We specifically sought to examine the extent to which the intervention improved ELs' reading comprehension, writing, vocabulary knowledge, and English oral proficiency (speaking and listening). In addition, we built on the prior study (Authors, 2021b) to investigate the mediation mechanisms by which the treatment contributed to the improvement of ELs' reading comprehension and writing outcomes. A better understanding of the mechanisms that account for the treatment effects may aid in the design of more effective and feasible intervention in subsequent iterations. In the current study, we addressed two research questions (RQ):

1. RQ1: To what extent does Tier-1 content-integrated literacy intervention improve ELs' reading comprehension, writing, vocabulary knowledge, and English oral proficiency outcomes?
2. RQ2: Do ELs' vocabulary knowledge and English oral proficiency mediate the treatment effects on reading comprehension and writing outcomes?

We proposed the following specific hypotheses. First, regarding RQ1, we hypothesized that ELs who participated in Tier 1 multicomponent content-integrated literacy intervention

would attain higher levels of reading comprehension, writing, vocabulary knowledge, and English oral proficiency relative to their peers who received business-as-usual instruction. Second, with respect to RQ2, consistent with the previous findings (e.g., Authors, 2021b), we hypothesized that an increase in vocabulary knowledge would mediate the treatment effects on the improvement of reading comprehension and writing outcomes, meaning that ELs' improvements in vocabulary knowledge would contribute to gains in reading comprehension and writing. Furthermore, ELs' English oral proficiency would also serve as a mediator of the treatment effects on the outcomes. That is, we expected the intervention to promote ELs' English oral proficiency, which in turn, fosters their reading comprehension and writing competencies.

Methods

Study Design and Participant Selection

This cluster randomized controlled trial (RCT) study was conducted in 30 elementary schools in a large, urban school district in the southeastern U.S. We preregistered the study design and conducted a power analysis to determine the minimum detectable effect size. We used a randomized block design, in which 30 schools were stratified into seven blocks based on demographic characteristics and academic performance. Within each block, half the schools were randomly assigned to treatment in first-grade treatment lessons (control condition in second grade) and half were assigned to second-grade treatment lessons (control condition in first grade). Thus, first-grade treatment schools provided valid counterfactuals for the second-grade schools, and vice versa. This randomized block design enabled us to determine minimum

detectable effect size and reduce unexplained variability in the outcome measures across school clusters (Raudenbush et al., 2007)[1].

The participants selected for the current study were ELs (N = 1,314; 47% male) who were classified as ELs by the school district and whose parents reported that a language other than English was spoken in their home. As shown in Table 1, 76% of the students were Hispanic/Latino, 15% were Asian, and 58% of the students were from low socio-economic status (SES) backgrounds. The average school-wide proportion of ELs across the participating schools was 31%.

Intervention Program

Intervention Unit Lessons

The MORE treatment curriculum was designed in a science and social studies thematic units in first and second grade that consisted of 10 lessons in each unit and was implemented during the content-area block in classrooms over the period of five weeks. The single theme for each unit was as follows: (a) first-grade science unit: *animal survival*; (b) first-grade social studies unit: *explorers*; (c) second-grade science unit: *dinosaur*; and (d) second-grade social studies unit: *inventors*. Each lesson comprised two sections: The first section (40 minutes) was designed to build domain and topic knowledge through interactive read-alouds of thematically and conceptually related informational texts, while the second section (45 minutes) was intended to cultivate knowledge application and transfer to new reading and writing tasks.

During the first section of each lesson, teachers began with establishing learning goals aligned with the unit mission and led the interactive read-aloud activity (20 minutes) to build

[1] Based on the effect sizes and intraclass correlation (ICC) from our previous study (Authors, 2021a), we targeted a sample size of 60 classroom clusters (30 treatment and 30 control groups) and 15 students per cluster. With an alpha level of 0.05 (two-tailed tests) on all models, MAP pretest reading covariate (R^2 = 0.50), and 80% power, the minimum detectable effect sizes were 0.25 across the student outcomes.

domain and topic knowledge through the science informational books. The activity was followed by students' equitable academic discussions, concept mapping activity using key science-specific vocabulary words (15 minutes), and reflection on learning goals (5 minutes).

In the second section of a lesson, students participated in a more expanded and in-depth concept mapping activity using resources from the texts and supplemental materials (15 minutes). They also engaged in a collaborative research activity focusing on text features and structures to obtain additional information on given concepts and participated in in-depth academic group discussions while incorporating relevant details and evidence from their research (25 minutes). Both Lesson 5 and 10 in the second section were modified to provide students with an opportunity to learn a self-regulated strategy, called "TREE," (**T**opic sentence, **R**easons, **E**xplain reasons, and **E**nding; Graham & Harris, 2005) to writing an argumentative response to an open-ended prompt (e.g., *Which animal will win the fight - polar bear or killer whale?*). Each lesson ended with a reflection on what students had learned throughout the lesson, what they had enjoyed, and what they still wanted to learn (5 minutes).

Professional Development

Teachers and literacy facilitators in the treatment group engaged in an half-day professional development meeting prior to the intervention implementation. The meeting was designed to support teachers' understanding of the program principles, core components, and instructional routines. The research team continuously provided treatment teachers with ongoing support and assistance along with more detailed guidance on lesson materials and implementation. Literacy facilitators at each school collaborated with the research team to address teachers' logistical and instructional questions.

Fidelity of Implementation

Table 2 displays the descriptive statistics of the fidelity of implementation (FOI) evaluation. Three dimensions of FOI were assessed: (a) adherence to the core intervention components, (b) exposure to instructional time, and (c) program differentiation.

Adherence to the Core Intervention Components

Treatment teachers' adherence to the core components was observed based on audio-recordings and evaluated using the adherence checklist with 11 essential indicators of the intervention core components. We collected an audio-recorded lesson from randomly selected 25 treatment teachers across the six schools (randomly selected two schools from each of the three poverty strata: low, middle, and high) during the implementation period. An adherence score for each of the 25 lessons was obtained based on the tallied presence-absence status of each of the 11 indicators. On average, 25 teachers achieved 98% adherence to the components (range = 80-100%). Inter-rater agreement between the independent coding results of two coders for randomly selected 11 lesson audio-recordings was 91% (Cohen's $\kappa = 0.63$).

Students' Exposure to Reading, Science, and Social Studies Instructional Time

Drawing upon a survey of both treatment- and control-group teachers, we explored the amount of time that they had spent on reading, science, and social studies classes over the course of the intervention. Treatment teachers, on average, spent approximately 20 minutes/week less on English Language Arts (ELA)/reading instruction than control teachers. However, treatment teachers reported spending nearly 60 minutes more on science and social studies instruction relative to their counterparts.

Program Differentiation

We evaluated how the current intervention was different and distinguishable from the business-of-usual condition by exploring (a) a complexity level of science and social studies

texts used for read-aloud activities and (b) openness of the literacy tasks (Parsons et al., 2015). A higher level of openness meant that literacy tasks were more likely to promote student engagement and student-centered learning than tasks with lower openness scores (Duke et al., 2006).

First, for text complexity, we asked control teachers to provide the titles of books used for their read-aloud activities over the implementation period and then we obtained the Lexile levels of those books. The list of book titles is available in Online Supplemental Material (OSM) Appendix A. As shown in Table 2, the average Lexile levels of the informational books used in the treatment group was far higher than those from the control group. Second, to assess openness of the literacy tasks, we used audio-recordings of 49 randomly-selected ELA/reading lessons, identified the types of literacy tasks, and rated the following five characteristics of each literacy task on a 3-point Likert scale (1 = *closed*, 2 = *moderately open*, and 3 = *open task*): authenticity (simulating real-life activity), collaboration (collaborative or independent activity), challenge (intellectually stimulating activity), student-directed work (involvement of student input), and sustained effort (sustainability over time). Overall inter-rater agreement ranged from 81 to 97% (Cohen's $\kappa = .68 – .96$). The literacy tasks in treatment were more likely characterized as authentic, collaborative, challenging, student-directed, and sustained relative to those observed from the control classrooms.

Measures

Reading Comprehension

Two measures were employed to assess students' overall reading comprehension: (a) The Measure of Academic Progress (MAP) Primary Grade Reading (Northwest Evaluation

Association, 2011) and (b) World-Class Instructional Design and Assessment (WIDA™) ACCESS for ELLs® 2.0 (hereafter WIDA) reading test.

MAP Reading. The MAP Reading test was used to assess students' reading comprehension before (pretest) and after (posttest) the intervention implementation. The MAP Reading is a computerized adaptive assessment to measure K-2 students' abilities or growth in reading comprehension using the Rasch unit (RIT) scale. The MAP Reading RIT score was computed based on students' performance on four specific areas: literature and informational text comprehension, vocabulary use and functions, foundational skills, and language and writing. Test-retest reliabilities ranged from .89 to .96 (Brown & Coughlin 2007).

WIDA Reading. The WIDA screener was designed to assess English language proficiency of ELs based on WIDA's English language development standards (WIDA Consortium, 2015) that reflect the social and academic language needed and used in a K-12 school context. The WIDA reading test was to assess students' ability to process, understand, interpret, and evaluate written language. The test used a multistage adaptive test design that routed students to a low, middle, or high tier, depending on their ability level. Students read passages on the computer screen and selected a response to answer multiple-choice questions. A scale score for each language domain (i.e., reading, writing, speaking, listening) ranged from 100 to 600 accounting for the difficulty of the items and tasks determined by Rasch measurement models.

Writing

Students' writing ability was evaluated using two types of tasks: (a) argumentative writing in science and social studies and (b) WIDA writing.

Argumentative Writing. Students' argumentative writing in science and social studies was assessed on their knowledge of the elements and structure of an argument. Students received a short source passage for each domain that provided background information relevant to a topic along with an open-ended writing prompt (see OSM Appendix B): for instance, in science, *Should people be allowed to cut down trees in the rainforest?* (first grade) and *Do you think that an asteroid killed the dinosaurs? Why or why not?* (second grade). Students were guided to write an argument, explain the reasoning behind their argument, and include a conclusion.

Students' argumentative writing was evaluated using a genre-specific rubric (Graham et al., 2011) on three dimensions: *claim, evidence*, and *conclusion*. The *claim* dimension was scored on a scale from 0 to 2 (0 = *absence of a claim*; 1 = *a lack of clarity in a claim*; 2 = *presence of a clear, appropriate, or well-developed claim*). The *evidence* dimension was scored on a scale from 0 to 4 (0 = *absence of evidence statements or appropriate background knowledge*; 1 = *inclusion of textual evidence derived from the source text that was irrelevant to support the claim*; 2 = *the use of relevant background knowledge to support the claim but not found in the source text*; 3 = *inclusion of at least one piece of relevant textual evidence from the source text to support the claim*; 4 = *the use of at least two pieces of relevant textual evidence to support the claim*). The *conclusion* dimension was rated as 0 or 1 depending on the presence of an appropriate concluding statement (0 = *absence*; 1 = *inclusion of a well-developed conclusion*). A toral score was calculated by summing the three-dimensional scores, ranging from 0 to 7.

Two raters or argumentative writing participated in extensive training and practice process using the scoring manual and anchor texts and reached a high level of inter-rater agreement (≥ 90%) after rating nearly 14% of the writing sample. The final scores were determined by consensus reached by the raters and one of the authors after discussion to resolve

discrepancies. The raters continued to score the remaining compositions independently and the inter-rater reliabilities for the randomly selected 20% of writing sample ranged from .92 to .99 (Cohen's κ) for total scores.

WIDA Writing. The WIDA writing assessment was administered on a paper test form. Students first read prompts and responded to writing prompts on a paper test form within 35 (first grade) or 60 (second grade) minutes. Students' handwritten test form was sent to the Data Recognition Corporation (DRC) for scoring. Each written text was evaluated based on three specific criteria and dimensions: (a) linguistic complexity in the discourse dimension, (b) language forms and conventions in the sentence dimension, and (c) vocabulary usage in the word/phrase dimension.

Vocabulary Knowledge

The semantic association task (Read, 2004) was used to assess students' vocabulary knowledge of the science and social studies words taught and incidentally encountered in the lesson units and their ability to identify and connect semantically related words. There were 24-item (12 science and 12 social studies) semantic association tasks (see OSM Appendix C). Each item presented a target word and four-word options. The seven target words out of the 12 words (or items) in each domain were the words that the treatment teachers explicitly taught during the concept mapping and argumentative writing activities. The rest of the five words were not directly taught, but students incidentally encountered those five words through reading, listening, and discussion. In the semantic association task, students were prompted to circle two words among the four options that were semantically associated with the target word. Each item was scored 0 to 4 (see OSM Appendix D for the scoring system). Internal consistency (Cronbach's α) was .91.

English Oral Proficiency

To assess students' English oral proficiency, two sets of WIDA scale scores were obtained: (a) speaking and (b) listening.

WIDA Speaking. Students listened to prerecorded speaking prompts from the computer and spoke into headsets to respond to the prompts. The speaking test session lasted for 30 minutes. Students' responses were automatically recorded and sent to DRC for scoring. Similar to WIDA writing, speaking proficiency was rated using the rubric with three criteria: linguistic complexity, language control, and vocabulary use.

WIDA Listening. Students listened to prerecorded listening passages through the computer and then answered multiple-choice questions on the computer screen within 40 minutes. Similar to the WIDA reading, students were routed into one of three tracks (low, middle, or high) and received listening test items and tasks at an appropriate level of difficulty.

Control Variables

The control variables included in the analytic models were students' demographic characteristics (i.e., gender, race/ethnicity, low SES status, grade), school-wide proportion of ELs, and randomization school blocks. In addition, two pre-intervention reading scores were included in statistical analyses to control for baseline reading abilities: MAP reading and Dynamic Indicators of Basic Early Literacy Skills (DIBELS) scores. A composite score of DIBLES was created based on the subtests of sound fluency, phoneme segmentation fluency, letter naming fluency, nonsense word fluency, oral reading fluency, and retell abilities. Test-retest and inter-rater reliabilities of the composite score ranged from .88 to .98 across grades.

Analysis Plan

Main Impact Analysis

We investigated the intervention effects on reading comprehension, writing, vocabulary knowledge, and English oral proficiency, using a two-level hierarchical linear model (HLM; Raudenbush & Bryk, 2002) in which students (Level 1) were nested within school (Level 2). The two-level HLMs used to estimate the intervention impact are expressed as follows:

$$Y_{ij} = \beta_{00} + \beta_{01}(TREAT)_j + \beta_{10}(MAP\_PRE)_{ij} + \beta_{20}(DIBELS\_PRE)_{ij} + \sum_{p=3}^{6} \beta_{p0}(COV)_{ij} + \beta_{02}(EL\%)_j + \sum_{q=3}^{8} \beta_{0q}(BLOCK)_j + \varepsilon_{ij} + \zeta_{0j},$$

where Y_{ij} denotes the posttest outcomes for student *i* in school *j*. *TREAT* is a dichotomous variable indicating treatment assignment; *MAP_PRE* and *DIBELS_PRE* represent students' pretest (baseline) MAP and DIBELS reading scores, respectively; *COV* indicates student-level demographic covariates; *EL%* represents the percentage of students with EL status in each school; and *BLOCK* refers to dummy-coded randomization school blocks. The model included random effects at student (ε_{ij}) and school (ζ_{0j}) level, assumed to be normally distributed. The outcome variables were standardized across the sample (by grade). We calculated an effect size (i.e., covariate-adjusted Cohen's *d*) by dividing the parameter estimate for *TREAT*, β_{01}, by the unadjusted pooled within-group standard deviation. The effect size metric captures the treatment-control difference in standard deviation units.

Mediation Analysis

Figure 2 displays the hypothesized mediation models for (a) reading comprehension and (b) writing outcomes. These models were specified to evaluate the treatment effects on reading comprehension and writing mediated by changes in vocabulary knowledge and English oral proficiency, after controlling for the covariates.

Measurement Models. For the first stage of the mediation analysis, we examined a measurement portion of the final model by fitting confirmatory factor analysis (CFA) models to

determine whether the four latent factors—vocabulary knowledge, English oral proficiency, reading, writing—were well represented by their respective observed measures. The following goodness-of-fit indices were used to assess how well the models fitted the current data: comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Adequate or excellent model fit is indicated by a CFI and TLI above .95, and RMSEA and SRMR values lower than .06 (Hu & Bentler, 1999).

Structural Models. We fitted two structural models (reading and writing outcome models) using three analytic approaches. First, we used full information maximum likelihood estimation to address a small amount of missing data. Second, to account for the nested data structure, we estimated robust standard errors that adjust for clustering using the TYPE = COMPLEX command in *Mplus* version 8 (Muthén & Muthén, 2017). Third, we used bias-corrected bootstrapped standard errors using 1,000 draws to construct 95% confidence intervals (CIs) for the direct and indirect paths. We evaluated the overall model fit relative to cutoffs specified by Hu and Bentler (1999).

Results

Preliminary Analysis

Table 3 displays descriptive statistics of pretest and posttest measures by treatment conditions and correlation matrix. Although 1,314 ELs (n = 681 treatment; n = 633 control) were initially recruited for the current RCT study, post-randomization attrition occurred due to students' absence at posttest. The final analytic sample included 1,236 ELs (n = 639 treatment; n = 597 control) who completed both pre and posttest in MAP reading. We found a statistically significant difference between the two groups in baseline MAP reading (treatment: M = 166.48,

SD =16.95; control: *M* = 168.79, *SD* = 16.96) (p = .02); thus, the baseline MAP reading scores were included in the statistical models to reduce bias in the estimate of the treatment effects. The baseline DIBELS reading scores were not significantly different between the groups (p = .32).

RQ1: Main Effects of MORE Intervention

Results from the two-level HLM main effect analyses are presented in Table 4. We found statistically significant positive treatment effects on WIDA reading (ES = .08, $p < .05$), argumentative writing in science (ES = .27, $p < .01$) and social studies (ES = .41, $p < .001$), vocabulary knowledge in science (ES = .51, $p < .001$) and social studies (ES = .53, $p < .001$), and WIDA listening (ES = .14, $p < .01$), after controlling for student- and school-level covariates. We further found that statistically significant treatment effects on vocabulary knowledge of science taught (ES = .44, $p < .001$) and untaught (ES = .48, $p < .001$) words and social studies taught (ES = .54, $p < .01$) and untaught (ES = .30, $p < .001$) words. There was no evidence of statistically significant treatment effects on MAP reading and WIDA writing and listening ($ps > .05$).

RQ2: Mediation Effects

Measurement Model Testing

We first assessed the validity of the four measurement models using CFA: reading comprehension, writing, vocabulary knowledge, and English oral proficiency. Goodness-of-fit statistics indicated that the four measurement models provided a satisfactory fit to the data (CFI = .96 to .99; TLI = .93 to .99; RMSEA = .03 to .04; SRMR = .01 to .04). The loadings of the measured variables on the latent factors were all statistically significant ($p < .001$) with the standardized factors above .52 (see OSM Appendix E), indicating that all three latent factors

were well represented by their respective indicators. Therefore, the good fit of the measurement models provided support for the subsequent examination of the structural mediation models.

Structural Mediation Models

The first structural mediational model with reading outcome (see Figure 2 [a]) provided an excellent fit to the data (CFI = .98, TLI = .97, RMSEA = .03, SRMR = .03). The direct path from treatment to reading comprehension was not statistically significant (β = -.04, *SE* = .02, bias-corrected [BC] bootstrapped 95% CI = -.08 to .00), after accounting for the mediators and control variables. However, we found positive and statistically significant point estimates of a path from treatment to vocabulary knowledge ($p < .05$) and a path from vocabulary knowledge to reading comprehension ($p < .001$). The indirect effect of treatment on reading comprehension through vocabulary knowledge was statistically significant (indirect effect = .05, *SE* = .01, BC bootstrapped 95% CI = .03 to .08). This finding implies that ELs' participation in the intervention was associated with improvement of vocabulary knowledge, which, in turn, positively affected reading comprehension.

Two additional direct paths were also statistically significant as shown in Figure 2(a): a path from treatment to English oral proficiency ($p < .001$) and a path from English oral proficiency to reading comprehension ($p < .01$). This finding indicates that ELs' participation in the intervention significantly improved their English oral proficiency which, in turn, positively affected reading comprehension. The indirect effect of treatment on reading comprehension via English oral proficiency was statistically significant (indirect effect = .01, *SE* = .01, BC bootstrapped 95% CI = .002 to .03). The total indirect effects were statistically significant (total indirect = .06, *SE* = .01, BC bootstrapped 95% CI = .04 to .09).

The second structural mediation model with writing outcome (see Figure 2 [b]) obtained an adequate fit to the data (CFI = .95, TLI = .93, RMSEA = .04, SRMR = .04). Similar to the reading comprehension model in Figure 2(a), the direct effect of treatment on writing was not statistically significant (β = .04, *SE* = .05, BC bootstrapped 95% CI = -.06 to .12). The indirect effect of treatment on writing via vocabulary knowledge was not statistically significant (indirect effect = .01, *SE* = .02, BC bootstrapped 95% CI = -.04 to .06), given the statistically non-significance in a direct path from vocabulary knowledge to writing ($p > .05$) despite the statistically significance in a path from treatment to vocabulary knowledge ($p < .05$). However, the indirect effect of treatment on writing via English oral proficiency was statistically significant (indirect effect = .04, *SE* = .02, BC bootstrapped 95% CI = .01 to .08), suggesting that the intervention treatment significantly contributed to improving English oral proficiency ($p < .001$), which was positively associated with improvement in writing outcome ($p < .01$).

Discussion

The goal of the current study was to advance the extant research base by evaluating the effects of Tier 1 content-integrated literacy intervention for first- and second-grade ELs who were learning to read in English as an additional language using a cluster RCT design. Specifically, we replicated and extended our previous findings (Authors et al., 2021b) suggesting that first- and second-grade general classrooms that emphasized the role of domain and content knowledge schema development in supporting students' ability to read content-rich informational texts can promote not only ELs' WIDA reading and listening proficiency but also science and social studies vocabulary knowledge and argumentative writing performance. In addition, moving beyond the question of whether and to what extent the treatment affected ELs' learning outcomes, we addressed the question of how the treatment affected English reading

comprehension and writing outcomes through the mediators. We intended to build an understanding of the mechanisms and processes through which the instructional practices in the intervention contributed to how ELs learned and gained English reading comprehension and writing competencies. The findings support the theoretical conjecture that practices of constructing and transferring content knowledge can bolster ELs' deeper understanding of semantically related concepts and their abilities to read and write complex texts (Anderson & Freebody, 1981; Kintsch, 1988).

Effects of Tier 1 Content-Integrated Literacy Intervention on ELs

We aimed to understand whether and to what extent Tier 1 content-integrated literacy intervention improved ELs' reading comprehension, writing, vocabulary knowledge, and English oral proficiency. The results of our main treatment effects suggest that primary-grade core classroom literacy instruction that underscored knowledge-building and knowledge-integration processes through thematically related informational texts improved ELs' academic language proficiency in reading and listening domains, argumentative writing skills, and domain-specific vocabulary knowledge. These outcomes are considered unconstrained skills that typically develop longer and slower than constrained skills (Paris, 2005) and that represent the critical source of variability in predicting reading comprehension of increasingly complex texts (Catts et al., 2005; LARRC, 2015; Vellutino et al., 2007).

One notable aspect of the results is that ELs in the treatment group outperformed those in the control condition on the measure of vocabulary knowledge in both science and social studies with effect sizes of .51 and .53 respectively. This echoes previous research findings that content literacy instruction resulted in positive effects on domain-specific vocabulary knowledge (cf. Authors, 2021b). In particular, the effect sizes for untaught or incidentally learned science and

social studies vocabulary knowledge outcomes among ELs (ES = .48 and .30, respectively) were higher than those previously found among the general population (ES = .45 and .28, respectively). It is important for ELs to learn domain-specific academic vocabulary that represents broad concepts and ideas as an essential element of disciplinary content learning (Author, 2021c; Nagy & Townsend, 2012; Schleppegrell, 2004) because it is challenging for many young ELs to grasp disciplinary concepts in content-rich complex texts as they acquire English proficiency and concurrently build content knowledge required at their respective grade level. The findings of significant effects on ELs' vocabulary knowledge might be attributable to vocabulary network building or concept mapping approach, in which ELs were engaged in gradual network development for semantically associated words across domains (i.e., science and social studies) that were learned incidentally during read-alouds and class discussions. As the network becomes larger with newly added words, it provides deeper and more nuanced elaboration of core concepts that can increase students' cognitive accessibility to mental representations of the semantic properties (Author 2021c; Newman et al., 2006; Steyvers & Tenenbaum, 2005). Consequently, ELs who often face additional cognitive load of language processing can benefit from building larger and richer mental semantic networks that may reduce cognitive burden and facilitate more automatic and strategic retrieval of word meaning and understanding of conceptually associated texts.

In addition to vocabulary knowledge, the intervention implementation contributed to ELs' argumentative writing with effect sizes of .27 and .41 in science and social studies, respectively. This finding substantiates our earlier evidence that first- and second-grade students in the treatment group improved significantly in their ability to compose a response with claims, reasons, and text-based evidence to support their claims as compared with their control group

counterparts (Authors, 2021a; 2021b). The finding suggests that ELs can benefit greatly from the opportunities to acquire knowledge of argumentative essay structures (De La Pax, 2005; Ferretti et al., 2009) and to apply their knowledge to produce argumentative texts (Olinghouse et al., 2015). The argumentative writing task involves not only linguistic knowledge and competence but also content knowledge stored in long-term memory (e.g., what to write about) and discourse knowledge about argumentation (e.g., how to write) (Bereiter & Scardamalia, 1987; McCutchen, 1986; Olinghouse et al., 2015). The treatment group ELs who participated in content knowledge-building practices in a thematic unit and explicit argumentative writing instruction may be able to gradually form a mental representation of content and discourse knowledge and to retrieve relevant knowledge stored in mental structures while addressing the argumentative writing prompt.

Similar effect sizes obtained from the ELs population to those from the general (ELs and non-ELs) population (Authors, 2021b) suggest that ELs who comprised approximately 31% of the student population can benefit equally as their non-EL peers from high-quality, evidence-based Tier 1 literacy instruction. This is convergent with previous research findings suggesting that effective instructional practices for all children also benefits ELs (e.g., Carlo et al., 2004; Lesaux et al., 2014; Vaughn et al., 2022).

The positive treatment impacts on ELs' receptive language skills such as WIDA reading (ES = .08) and listening (ES = .14) are also noteworthy. The current study is one of the few to explore an RCT intervention that focuses on developing primary-grade students' academic language and literacy, anchored in science and social studies content, and its impact on young EL population. This multi-component content-integrated literacy intervention may have created a language-rich classroom environment in which ELs had opportunities to receive exposure to

academic language through the use of complex texts during the interactive read-aloud activity and to engage in high-level discourse with their ELs and English-speaking monolingual peers during the research collaboration activity. Such equitable instructional experiences and exposure to cognitively demanding language and content learning are critical to promoting ELs' educational equity and access to rigorous learning opportunities (Callahan, 2005; Darling-Hammond, 2007).

Notably, the current intervention study was conducted in an urban school district with the sample of ELs mostly from low-SES neighborhoods and underrepresented racial and ethnic groups. Many ELs from low-income households have fewer opportunities to access challenging and complex texts, to experience English academic language use, or to engage in higher-order thinking through interactive discussion or research collaboration. The present study demonstrated that when young ELs have the opportunity to engage in such rigorous practices, meaningful learning in several domains may occur.

Despite ELs' significant gains in multiple outcomes above, we found statistically non-significant differences between the treatment and control conditions on the MAP reading measure. This finding suggests that the intervention that integrated content learning in literacy instruction produced the intended effects without the expense of ELs' reading comprehension and foundational literacy skills relative to their English-speaking monolingual peers in the typical instruction condition. Moreover, the absence of significant differences on these measures, particularly for reading comprehension, is consistent with the findings from previous RCT literacy intervention studies (e.g., Authors, 2021b; Connor et al., 2014; Lesaux et al., 2014). One plausible explanation could be that the distal measure like MAP reading may be inadequately sensitive and precise to detect content-focused literacy intervention impacts whereas researcher-

designed measures (e.g., domain-specific vocabulary knowledge, argumentative writing) were aligned most closely with the targets of the intervention implementation and curriculum materials. Moreover, we did not find significant improvement in reading compression measured by MAP reading after the 20-lesson intervention presumably because reading comprehension is considered an unconstrained and complex reading skill that develops gradually and incrementally over time and it may take a sustained multi-year intervention to observe substantial gains in reading comprehension especially in second language.

Mediators of the Intervention Impacts

In addition to our investigation of the main treatment effects, we explored the mediation factors of the intervention leading to ELs' reading comprehension and writing outcomes. This study helps us extend our understanding of how the content-integrated literacy intervention promotes ELs' reading comprehension and writing directly and indirectly by presenting mechanisms that putatively underlie intervention impacts. Our findings provide mixed support for the two hypotheses that the content-integrated literacy intervention affected ELs' reading comprehension and writing through the positive changes in vocabulary knowledge and English oral proficiency.

First, in terms of reading comprehension outcome, there was no significant direct treatment effect on ELs' reading comprehension, but we found that the improvement of vocabulary knowledge functioned as a mechanism through which the intervention achieved the impact on ELs' reading comprehension. That is, the content-integrated literacy instruction promoted ELs' domain-specific vocabulary knowledge, which resulted in a consequent improvement in understanding texts. The predictive relation between vocabulary knowledge and reading comprehension is consistent with existent correlational studies among ELs (e.g., Crosson

et al., 2021; Kieffer & Lesaux, 2012; Lawrence et al., 2015), suggesting the importance of concept and vocabulary knowledge development in young ELs' English reading comprehension.

Additionally, we found that the intervention affected ELs' reading comprehension indirectly through English oral proficiency, controlling for vocabulary knowledge, baseline English reading ability (measured by MAP and DIBELS), and covariates. The classroom-based content-integrated literacy intervention bolstered ELs' English oral proficiency, which, in turn, fostered their English reading comprehension. The predictive association between ELs' English oral language and reading comprehension in the current mediational analysis is convergent with considerable empirical research evidence conducted among young bilingual readers (e.g., August & Shanahan, 2006; Author, 2015; Droop & Verhoeven, 2003; Leider et al., 2013). The effect of the intervention on reading outcome for ELs was, therefore, characterized by indirect effects via the mediators of vocabulary knowledge and English oral proficiency. Yet, interestingly, the magnitude of the indirect effect via vocabulary knowledge was greater than that via English oral proficiency, suggesting that vocabulary knowledge is relatively more critical to the development of English reading comprehension for ELs (Lesaux et al., 2010; Snow et al., 2009).

Second, on the basis of the mediational analysis with writing outcome, we found that the hypothesis associated with writing was partially supported. In contrast to the preceding reading comprehension model and prior study findings (e.g., Authors, 2021b), we did not find a significant indirect effect of the intervention on the improvement of writing outcome through vocabulary knowledge. However, for ELs, English oral proficiency accounted for indirect effect of the intervention on writing outcome. These results partially replicate and extend those from the earlier study in important ways. Consistent with the previous findings based on the writing construct being an indicator of argumentative writing, we did not find evidence for direct effect

of the intervention on writing outcome as a global latent construct (e.g., argumentative writing and WIDA writing). In terms of indirect effects, our previous findings support a logic model wherein vocabulary knowledge significantly accounted for the indirect effect of the intervention on argumentative writing. However, the results from the current analyses, in which the latent construct of writing outcome represents a genre-general construct including argumentative writing and WIDA writing measures, indicate that treatment-group ELs' improved domain-specific vocabulary knowledge did not significantly predict the overall writing ability. This study expands on the previous findings by demonstrating that the current intervention can indirectly improve a global writing competence of ELs by way of affecting their English oral proficiency.

The much stronger association between English oral proficiency and writing ability than that between vocabulary knowledge and writing ability supports the notion that ELs' oral language competence in English is not only an essential component of writing development (August & Shanahan, 2006) but also a core means of developing conceptual knowledge and disciplinary literacy (Bravo, 2016; Bunch, 2014). The development of ELs' writing ability, especially in content areas, requires extensive instructional support and scaffolding of multiple aspects of English oral language proficiency, including listening comprehension, metalinguistic awareness, and syntactic and semantic knowledge. ELs' opportunities to engage in focused and coherent conversations with their peers and teacher in the context of science through interaction, collaboration, and discourse may have enhanced ELs' speaking and listening in English, which led to developing deeper conceptual understanding and argumentative thinking.

Limitation and Future Research

There are several study limitations that can inform future research. First, the core instructional components of the current intervention were closely aligned with practices

suggested in the IES WWC Educators' Practice Guide and Recommendations for ELs, resulting in positive outcomes, yet going forward, there is a need to provide tailored Tier 2 small-group supplemental instruction for ELs who may benefit from additional support beyond Tier 1 lessons, as suggested in Recommendation 4 (Baker et al., 2014). Providing systematic and coherent small-group instructional interventions above and beyond what the current Tier 1 instruction provides based on ELs' identified needs may yield complementary and synergistic beneficial effects on ELs' reading comprehension and writing competencies.

Second, although the current replication study examined how Tier 1 intervention works for an underrepresented U.S. school population, specifically ELs or emergent bilinguals, who bring rich language experiences to the classroom, there is a need to further explore how their home language and literacy skills may interact with content literacy instruction with regard to their language, reading comprehension, and content knowledge. Incorporating differentiated or individualized instructional practices based on ELs' native language skills and reading ability (e.g., child characteristics by instruction interactions [Connor et al., 2004]) in content-integrated literacy instruction may not only explain individual differences in their response to the instruction, but also allow us to design and implement more effective literacy instruction that can benefit *all* children.

Finally, future research on sustained, multi-year content-integrated literacy intervention is warranted. Previous intervention programs for elementary-grade students primarily target to improve unconstrained literacy competencies (e.g., Authors2021a, 2021b; Connor et al., 2017; Guthrie et al., 2004), but these programs, in general, are developed to be implemented in a relatively short period of time. Given that unconstrained competencies such as vocabulary knowledge and reading comprehension develop in a slow and gradual manner over time (Paris,

2005), particularly among ELs, more research is needed to design and implement a multi-year intervention (Authors, 2022) that may help us understand whether a sustained intervention can produce effects on the desired distal outcomes that can persist or amplify over time. Improved understanding of long-term intervention effects may lead to more nuanced theory development, more enhanced intervention design and implementation, and greater precision in measuring intervention impacts.

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Table 1

Baseline Demographic Characteristics of English Learners by Intervention Treatment Condition

Characteristics	Overall	Treatment	Control
N (All)	1,314	681	633
Grade 1	659	375	284
Grade 2	655	306	349
Gender			
Male	47%	50%	44%
Race/Ethnicity			
White	5%	5%	5%
Hispanic/Latino	75%	75%	75%
African American	3%	3%	4%
Asian	15%	15%	15%
% of low SES status	58%	58%	58%
Individualized education programs	9%	8%	9%
School-wide proportion of EL	31%	30%	32%
MAP pretest, *M* (*SD*)	167.60 (16.99)	166.48 (16.95)	169.79 (16.96)
DIBELS pretest, *M* (*SD*)	155.18 (110.97)	152.17 (106.90)	158.33 (115.09)

Note. SES = socioeconomic status. MAP = Measure of Academic Progress. DIBELS = Dynamic Indicators of Basic Early Literacy Skills.

Table 2

Descriptive statistics of Fidelity of Implementation

	Treatment		Control	
FOI components	*M*	*SD*	*M*	*SD*
Adherence	98.00%	5.70	n/a	n/a
Exposure to instruction time[a]				
ELA/reading instruction	485.94	244.02	505.30	258.91
Science instruction	164.51	126.84	103.25	88.50
Social studies instruction	161.68	123.44	103.69	90.62
Program differentiation				
Read-aloud text Lexile level				
Science texts	738.67L	120.35L	534.29L	137.10L
Social studies texts	876.92L	128.67L	439.09L	100.64L
Openness of literacy tasks				
Authenticity	2.65	0.39	1.64	0.54
Collaboration	2.63	0.27	1.61	0.36
Challenge level	2.60	0.51	1.24	0.30
Student-directed work	2.59	0.46	1.59	0.44
Sustained effort	2.88	0.33	1.83	0.70

Note. [a]minutes per week. ELA = English Language Arts.

Table 3

Descriptive Statistics of Student-Level Measures by Treatment Conditions and Correlational Metrix

	Treatment			Control			Correlation													
Measures	*M*	*SD*	*n*	*M*	*SD*	*n*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reading pretests																				
1. MAP reading	166.48	16.95	650	168.79	16.96	615	--													
2. DIBELS reading	152.17	106.90	654	158.33	115.09	623	.78	--												
Reading comprehension																				
3. MAP reading	171.71	17.13	656	173.56	17.00	612	.89	.79	--											
4. WIDA reading	308.07	34.11	665	308.87	36.09	620	.75	.68	.75	--										
Writing																				
5. Science arg. writing	3.09	1.81	302	2.56	1.78	310	.34	.35	.37	.27	--									
6. SS arg. writing	3.62	2.15	269	2.81	1.89	292	.48	.42	.48	.41	.40	--								
7. WIDA writing	279.39	40.83	659	282.78	42.73	618	.71	.62	.71	.65	.24	.40	--							
Vocabulary knowledge																				
8. Science vocab. total	34.40	6.90	589	31.29	6.74	561	.54	.51	.57	.48	.29	.39	.44	--						
9. Science vocab. taught	20.18	4.36	589	18.55	4.46	561	.51	.48	.54	.45	.30	.32	.43	.90	--					
10. Science vocab. untaught	14.60	3.45	589	13.18	3.41	561	.46	.42	.47	.41	.18	.35	.37	.84	.67	--				
11. SS vocab. total	33.38	6.83	546	30.16	6.59	545	.50	.48	.51	.46	.27	.39	.37	.58	.53	.50	--			
12. SS vocab. taught	20.47	4.54	546	18.13	4.30	545	.41	.40	.43	.38	.28	.36	.30	.50	.45	.43	.88	--		
13. SS vocab. untaught	12.92	3.55	546	12.03	3.56	545	.43	.41	.43	.39	.15	.29	.34	.48	.44	.40	.80	.42	--	
English oral proficiency																				
14. WIDA speaking	253.88	52.40	665	253.87	52.96	620	.37	.32	.40	.32	.20	.17	.44	.25	.23	.19	.19	.18	.14	--
15. WIDA listening	328.61	55.54	665	322.25	58.34	620	.57	.44	.59	.46	.33	.34	.49	.38	.37	.30	.39	.37	.29	.46

Note. MAP = Measure of Academic Progress. DIBELS = Dynamic Indicators of Basic Early Literacy Skills. arg. = argumentative. vocab. = vocabulary. SS = social studies. WIDA = World-Class Instructional Design and Assessment.

Table 4

Two-Level Hierarchical Linear Modeling (HLM) Results of the Treatment Effects on English Learners' Reading Comprehension, Writing, Vocabulary Knowledge, and English Oral Proficiency Outcomes

	Coefficient (*SE*)								
	Reading comprehension		Writing			Vocabulary knowledge		English oral proficiency	
Sources	MAP reading	WIDA reading	Science argumentative	Social Studies argumentative	WIDA writing	Science[a]	Social studies[a]	WIDA speaking	WIDA listening
Fixed effects									
Intercept	.002 (.04)	.01 (.06)	-.27 (.13)*	-.47 (.11)***	-.08 (.08)	-.30 (.09)**	-.31 (.07)***	-.004 (.09)	-.04 (.06)
Treatment	.03 (.03)	.08 (.04)*	.27 (.09)**	.41 (.08)***	.05 (.06)	.51 (.06)***	.53 (.05)***	.01 (.07)	.14 (.04)**
MAP pretest	.65 (.02)***	.46 (.03)***	.34 (.06)***	.38 (.06)***	.40 (.03)***	.32 (.04)***	.31 (.04)***	.33 (.04)***	.71 (.03)***
DIBELS pretest	.26 (.02)***	.30 (.03)***	.12 (.06)*	.15 (.06)**	.29 (.03)***	.21 (.04)***	.20 (.04)***	.05 (.04)	-.12 (.03)**
School EL%	.16 (.11)	.12 (.17)	.54 (.39)	.70 (.31)*	.22 (.27)	.21 (.27)	.29 (.21)	.11 (.30)	.05 (.19)
Variance									
Level 1	.20	.45	.71	.67	.50	.65	.67	.77	.58
Level 2	.00	.00	.05	.01	.03	.02	.00	.03	.00
N	1,230	1,247	606	555	1,239	1,137	1,076	1,247	1,252

Note. Student-level demographic characteristics (i.e., gender, race/ethnicity, low socioeconomic status, grade) and school randomization blocks were included in HLM analyses as covariates but suppressed in Table 4. Standard errors are in parentheses. MAP = Measure of Academic Progress. DIBELS = Dynamic Indicators of Basic Early Literacy Skills. WIDA = World-Class Instructional Design and Assessment.

[a]A total score of the items for taught and untaught words combined.

†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Figure 1

Hypothesized Logic Model for Tier 1 Content-Integrated Literacy Intervention: Instructional Core Components, Mediators, and Outcomes

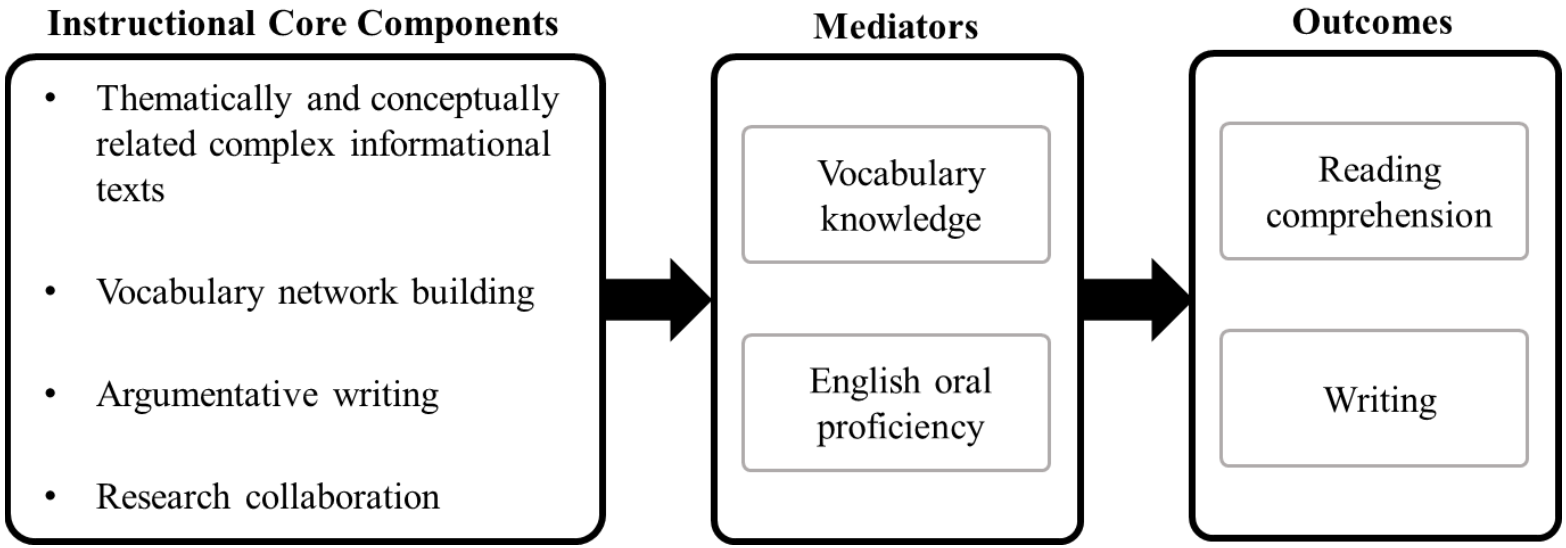
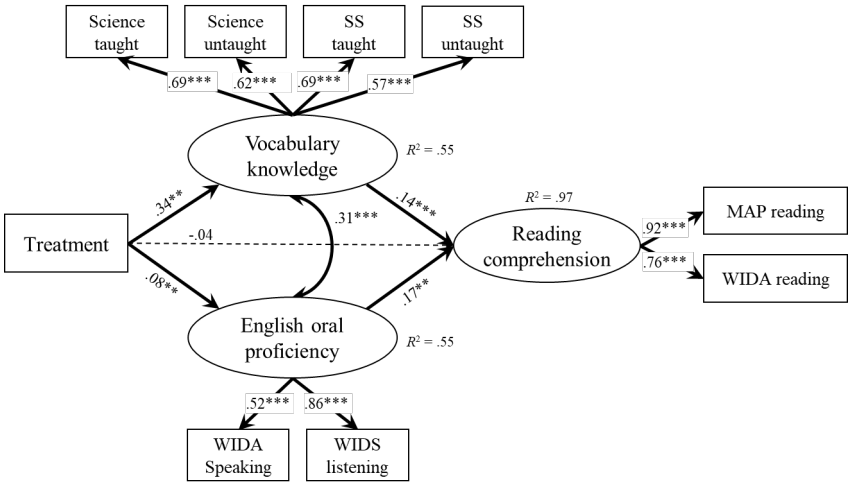


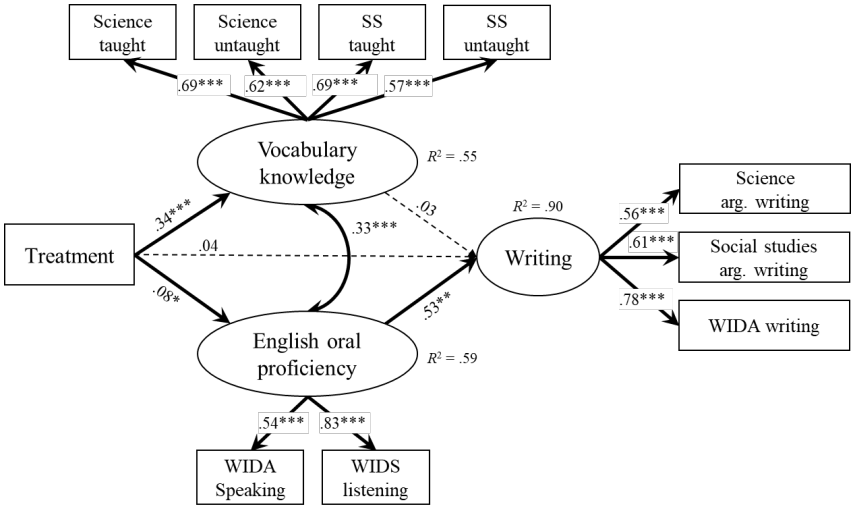
Figure 2

Results for the Structural Mediation Model of Direct and Indirect Effects of the Intervention on (a) Reading Comprehension and (b) Writing Through Vocabulary knowledge and English Oral Proficiency

(a) Reading comprehension outcome model



(b) Writing outcome model



Note. Statistically significant ($p < .05$) path coefficients are shown in bold. Path estimates are standardized and standard errors are shown in parentheses. Student- (i.e., gender, race/ethnicity, low socioeconomic status, grade) and school-level covariates (i.e., school-wide percentage of English learners, school randomization blocks) were included in the mediation analysis but not displayed in the path diagram. SS = social studies. arg. = argumentative. WIDA = World-Class Instructional Design and Assessment. MAP = Measure of Academic Progress.
*$p < .05$, **$p < .01$, ***$p < .001$.