Shared Reading and Science Vocabulary for Kindergarten Students

Anna S. Gibbs¹ · Deborah K. Reed¹

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Abstract

Kindergarten students commonly receive a limited amount of exposure to scientific concepts and informational texts. The present study used a multiple probe design across participants to determine the effects of shared reading instruction on three kindergarten students' science-related vocabulary acquisition in a virtual classroom during the Covid-19 pandemic. The interventionist delivered explicit vocabulary instruction by reading aloud a science picture book and intentionally pausing to define, explain, and discuss vocabulary words that were unfamiliar to young students. Researcher-developed vocabulary probes were administered every fifth instructional session and measured specific words taught during instruction. Results of virtual shared reading instruction indicate positive effects ($Tau-U=0.222-0.933$) on kindergarten students' science vocabulary learning. Students, their instructor, and caregivers all perceived the shared reading instruction as beneficial for science vocabulary development. These findings suggest explicit science vocabulary instruction during shared reading is beneficial to students and feasible for teachers to implement in a virtual classroom.

Keywords Early childhood · Instruction · Literacy development · Oral language · Vocabulary

Introduction

Children are naturally motivated to learn about their environment and the world in which they live, often asking questions (e.g., What is this?; How does it work?; Where does it come from?) to seek more information about things they observe in their daily lives (French, 2004). When students enter school, this inquisitiveness is encouraged during science instruction, as suggested by current science standards (e.g., Next Generation Science Standards [NGSS], 2013). Kindergarten students are expected to understand various scientific disciplines (e.g., life and earth science) and use language and literacy skills while learning those disciplines by asking and answering questions, describing, arguing, and explaining (Wright & Domke, 2019). These examples underscore the reciprocal relationships among science, reading, and language skills. That is, content-area learning supports reading and language skills, and reading and language skills support content-area learning (Cervetti et al., 2012). Thus, to master science standards, kindergarten students must

develop and demonstrate reading and language skills to communicate scientific knowledge (Wright & Gotwals, 2017).

Despite the demonstrated need for proficiency in both academic domains (i.e., science and literacy), the amount of instructional time dedicated to science vocabulary in the early elementary grades is limited (Wright & Gotwals, 2017). A meta-analysis confirms that read alouds are a common and effective method for teaching vocabulary to young students (Marulis & Neuman, 2010), but very little—if any—of that time is spent with informational texts such as those on science concepts (Wright, 2013). In fact, only 2.5 min of observed instructional time in kindergarten was focused on science-related content (Wright & Neuman, 2014). Nevertheless, time spent on science vocabulary instruction is only one challenge; quality of instruction also might be an issue. Observations in kindergarten classrooms reveal that teachers tend to rely on incidental rather than systematic approaches to introducing new words (Beck & McKown, 2007; Neuman et al., 2011). The combination of limited exposure to science content and informational texts as well as potentially less effective methods for teaching critical academic vocabulary may limit students' comprehension of the complex science texts they are likely to encounter in later school years (Mantzicopoulos & Patrick, 2010).

✉ Anna S. Gibbs
anna-gibbs@uiowa.edu

¹ Iowa Reading Research Center, University of Iowa,
Iowa City, IA 52242, USA

Effective Vocabulary Instruction

Although children will learn many words incidentally, decades of research findings have established that the most effective approach to helping students learn academic vocabulary involves explicitly teaching selected words and providing students multiple opportunities to encounter and work with those new words (Marulis & Neuman, 2010). This includes providing child-friendly definitions, examples of how to use new words in different contexts, and concrete and picture representations of the words (Beck et al., 2013). By contrast, implicit word learning occurs through repeatedly encountering a word by chance, or without intentionally manipulating the number and variety of exposures or purposefully focusing on particular words (Marulis & Neuman, 2010). Thus, students must notice the new word and infer its meaning on their own. In comparing the effect of explicit and implicit vocabulary instruction on the vocabulary acquisition of young children, results have indicated that explicit vocabulary instruction is associated with better word learning outcomes (Hadley & Dickinson, 2019; Marulis & Neuman, 2010).

Because explicit vocabulary instruction often occurs in formal educational settings, some studies have explored the role that group sizes (i.e., whole group, small group, one-to-one) play in students' word learning (Marulis & Neuman, 2010; Neuman & Kaefer, 2013). Although the findings are not conclusive, there is little to suggest that group sizes are related to students' word learning or engagement. To our knowledge, no published research has examined the effectiveness of explicit vocabulary instruction implemented via videoconferencing with young children in any group size. Given the literature gap and pressing need to understand how students learn during times when schools must deliver remote instruction, this study explored the effects of explicit vocabulary instruction delivered to kindergarten students in a one-on-one setting via videoconferencing.

Science Vocabulary Instruction

Early exposure to content-specific language supports students' learning in science (Fang, 2012; Nagy & Townsend, 2012) and is emphasized by the Next Generation Science Standards (NGSS, 2013). Vocabulary instruction often focuses on general academic words, or those of high utility and that appear across various domains (Beck et al., 2013). Nevertheless, knowledge of domain-specific words (e.g., hooves, desert, photosynthesis, sedimentary rock) may support students' ability to communicate their scientific knowledge (Mantzicopoulos & Patrick, 2011; Reed

et al., 2017; Wright & Domke, 2019). Consistent with the features of effective vocabulary instruction, the technical language of science can be taught explicitly by providing clear definitions, explanations, and examples of the new word (Mantzicopoulos & Patrick, 2011; Pollard-Durodola et al., 2011).

Despite the importance of teaching science vocabulary to young children, science instruction in prekindergarten and kindergarten classrooms reportedly is limited (Wright & Gotwals, 2017). One reason may be that early elementary teachers lack confidence and self-efficacy in teaching science, and, consequently, opportunities for science instruction are reduced (Oppermann et al., 2019). Another reason may be a lack of science materials and manipulatives in early childhood classrooms (Saçkes, 2014). Given the importance of science vocabulary instruction and limited science instruction in the early elementary grades, the current study explored the feasibility and utility of teaching science and science-related vocabulary words during shared reading to kindergarten students in a virtual setting.

Shared Reading

Shared reading is an interactive process that involves an adult reading books aloud to a child and facilitating discussions about the words and content (Whitehurst et al., 1994). Teacher-led shared reading can be effective at improving content-area vocabulary knowledge, such as in science (Gonzalez et al., 2011; Neuman et al., 2011; Pollard-Durodola et al., 2011). In fact, Gonzalez et al. (2011) implemented teacher-led shared reading to improve the science and social studies vocabulary knowledge of preschool students. In classes randomly assigned to the experimental instruction, the informational books complemented the weekly science or social studies theme. Classes randomly assigned to the business-as-usual (BAU) condition were observed implementing shared reading with storybooks and devoting limited time ($M=2.13$ min) to teaching vocabulary. Findings indicated that students who participated in the content-area shared reading outperformed their peers in BAU instruction on standardized and researcher-developed vocabulary outcome measures. What is not possible to know from these results is which content area (science or social studies) had greater impact on vocabulary acquisition. Thus, the present study focused on vocabulary words related to science.

Purpose and Research Questions

Although there is evidence that effective vocabulary instruction can be delivered during shared reading with young students (Marulis & Neuman, 2010), less is known about the feasibility and utility of teaching vocabulary words about science concepts during informational book reading,

particularly in a virtual setting. Therefore, the present exploratory study sought to contribute to the literature by addressing the following research question: What are the effects of virtual shared reading instruction conducted with science-related informational books on the vocabulary development of kindergarten students?

Method

Research Design

A multiple probe across participants design was conducted to determine the effects of shared reading instruction on kindergarten students' science-related vocabulary acquisition in a virtual classroom. In multiple probe designs, student data are collected intermittently rather than continuously during baseline (Kennedy, 2005). This design was preferred over multiple baseline to reduce the potential for practice effects influencing results because the baseline probes assessed students' knowledge of taught vocabulary. Hence, the often protracted period in a multiple baseline with daily probe administration would give students who entered the instructional phase later more exposure to the vocabulary words before they ever participated in the shared reading. However, this weakness of the multiple baseline design can be mitigated with a multiple probe design in which the baseline probe items are randomly selected and participants are only exposed to each item one time during the baseline phase.

Setting

With the exception of standardized pretests administered in person, the study was implemented over a password-protected videoconferencing platform with three kindergarten students from one elementary school in a mid-size city in the Midwestern region of the United States. The principal had requested assistance with designing and delivering remote instruction during the COVID-19 pandemic, so the Institutional Review Board determined the study to be an evaluation of educational practices not requiring informed consent. The instructor had a master's degree and 14 years of experience teaching kindergarten in public schools. Her regular teaching position was in a different school from the one that the student participants attended.

Participants

Three kindergarten students were selected to participate in the study based on their parents' request for reading tutoring support to supplement the daily reading instruction provided in their school's online learning program during the COVID-19 pandemic. Caregivers of all three

students signed a release authorizing their children to be recorded in each session for evaluation purposes. Martin and Antonio were 6 years old, and Omar was 5 years old. All students were Caucasian and native English speakers. Only Omar was identified with a disability, which was in speech. None of the students qualified for free or reduced-price lunch. Because these were incoming kindergarten students enrolled in remote instruction during the pandemic, the only baseline academic data available were the data we collected as part of the study (see [Results](#)).

Standardized Assessments

Two standardized vocabulary assessments were individually administered to students prior to the start of instruction in order to establish baseline abilities: the Peabody Picture Vocabulary Test, fifth edition (PPVT-V; Dunn, 2019), and the Expressive Vocabulary Test, third edition (EVT-III; Williams, 2019). Both assessments were individually administered by the lead researcher in a distraction-free setting in each child's home. Although the instruction was delivered virtually, these measures were not validated for virtual administration, so they were completed in person and adhering to health safety protocols.

The PPVT-V and EVT-III are untimed assessments that each take approximately 20–30 minutes to administer. Students have approximately 10 seconds to respond to the administrator's prompt, and the administrator can repeat the prompt one time per item. Both standardized assessments require students to achieve a basal, or three consecutive correct responses to the first items. Students begin the assessments with the item which corresponds with their age. If a student does not achieve the age-appropriate basal, items preceding the start point are administered in reverse order until a basal is achieved. Additionally, the PPVT-V and EVT-III require students to reach a ceiling rule before discontinuing the assessment. A ceiling is achieved when students receive six consecutive 0 scores, indicating the items that follow are beyond the students' ability.

The PPVT-V measures receptive vocabulary by having students select from provided illustrations the one that represents an object or action stated by the examiner. Publishers report the PPVT-V demonstrated an alternate form reliability of corrected $r = 0.81$, split-half reliability of 0.97 to 0.98, and test–retest reliability of corrected $r = 0.89$ (Dunn, 2019). The EVT-III measures expressive vocabulary knowledge by prompting students to generate synonyms of vocabulary words and verbally label pictures (Williams, 2019). Publishers report the EVT-III demonstrated alternate form reliability of corrected $r = 0.86$,

split-half reliability of 0.95 to 0.98, and test–retest reliability of corrected $r = 0.87$ (Williams, 2019).

Researcher-Developed Assessments

Science vocabulary knowledge was measured during the baseline phase according to the multiprobe design, weekly during the instructional phase, and in the maintenance phase 1 week after the end of the shared reading sessions. The vocabulary probes were researcher-developed, and each administration included five words from the total of 30 science-related vocabulary words included in the intervention. The 30 vocabulary words initially were selected by the research team from the informational science books identified for the shared reading instruction (see section on materials). Two kindergarten public school teachers vetted the selected words by indicating whether they agreed the words were appropriate for kindergarten students (see section on materials).

Baseline and maintenance probes consisted of a random selection of five of the 30 total targeted vocabulary words, and the lead researcher administered these measures virtually to individual students. For baseline, once a word was selected for a probe, it was ineligible to be selected for subsequent baseline probes to avoid practice effects. Because participants only received one probe during the maintenance phase after being taught all 30 vocabulary words, the 5 words on the maintenance probe were randomly selected from the pool of 30 words.

Session probes were administered by the teacher over Zoom every fifth day of the instructional phase and contained a random selection of five of the six words introduced during that week of instruction. During all three phases, the assessment administrator (i.e., researcher or teacher) prompted students to define the meaning of the vocabulary words by stating, “*I am going to say a word and ask you to tell me the meaning of the word. [Word]. What is the meaning of [word]?*” Students received unlimited time to respond, and the administrator scored each response for accuracy, using a rubric developed by the research team. Students could earn 0–2 points per word, with a total possible score of 10 points per probe. Two points were awarded if a student correctly defined the target word or used the target word in a sentence. One point was awarded if the student provided an easier or more frequently-used word with the same meaning as the target word; and no points were awarded if the student misused the target word in a sentence, provided an incorrect example of the target word, or did not offer a response.

Interobserver Agreement (IOA)

All vocabulary measures were scored twice: once by the test administrator and once by an independent scorer. Scorers

were trained using sample audio recordings not associated with this study. They were required to meet the 90% agreement standard before scoring students in the present study. Reliability of all test administrations was determined using point-by-point agreement [i.e., number of agreements/ (number of agreements + number of disagreements) $\times 100$; Kazdin, 1982]. Any disagreements were resolved by having the two scorers review and discuss the item until achieving a mutual agreement.

Independent Variable

The instruction consisted of 20-min shared reading sessions delivered to individual students in a virtual setting four days per week for 5 weeks. Each session involved the study teacher, who was not on staff at the students’ elementary school, reading aloud specified science-related informational books and introducing selected vocabulary words aligned to earth science. Students’ participation in the sessions for this study supplemented their typical instruction and occurred outside of the time planned for their remote instruction delivered by their typical schoolteacher.

Materials

In addition to the researcher-developed assessments, study materials included informational science books, target vocabulary words, and lesson scripts. The research team consulted with an elementary school librarian to select the informational science books that met the following selection criteria: (a) be informational books featuring age-appropriate scientific concepts, (b) include at least three science-related vocabulary words appropriate for teaching to kindergarten students, (c) be written with age-appropriate language and content, and (d) include supportive illustrations. The librarian provided a sample of 18 informational science books for instruction; however, only 10 informational science books were needed for the study as two books would be read aloud to students per week across five weeks.

Using the criteria above, two certified kindergarten teachers were asked to independently rank-order the 18 books by priority to determine their inclusion in the final materials. The pair agreed on 10 books to include in the study, 5 books to be alternate books, and 3 books to exclude from the study. The alternate books were included in the event any of the 10 books originally identified had to be replaced because they did not contain at least three target vocabulary words that were different from words in the other books or contained target words that are too challenging for kindergarten students.

Once the final 10 books were identified, the research team again evaluated the content to identify three words per book for a total of 30 vocabulary words for instruction

during the shared reading sessions. Just over half (54%) of the vocabulary words consisted of polysemous vocabulary words that had a science-specific meaning and one or more meanings that might apply in other contexts (e.g. *escape*, *harsh*, *protect*). Another 23% of the vocabulary words consisted of domain-specific science vocabulary words that did not have more common meanings (e.g. *Arctic*, *reef*, *algae*). The remaining 23% of words were not science-specific but were related to and supported understanding of the science concept presented in the book (e.g. *changing* was used in a book about weather, *nearby* was used in a book about an animal's senses). The same two kindergarten teachers independently reviewed the initial list of vocabulary words to ensure all were appropriate for kindergarten students to learn. We had planned that any words judged by one of the teachers as not age-appropriate was iteratively replaced by the research team and reviewed by the teachers until three words were approved per book, resulting in the total of 30 target words. However, this procedure did not occur as the teachers determined that all initially identified vocabulary words were appropriate for kindergarten students. The full list of intervention materials is shown in the supplemental materials.

Once the 10 books and 30 vocabulary words were identified and vetted, the research team developed lesson scripts for the instructor to follow during the shared reading instruction. Each of the 10 books contained three sticky notes (one for each target word) with a script for what to say when introducing a target vocabulary word during the shared reading instruction. Each sticky note was placed on the page in which the word occurred in the book. The sticky note provided the target vocabulary word, the sentence in which the target word was used in the book (i.e., storybook sentence), an age-appropriate definition of the target word, and an explanation of how to use the target word in a context different from the one in which the word appeared in the book.

Pretest and Baseline Phase

Students received the PPVT-V, EVT-III, and vocabulary pretest separately, on three consecutive days. Following pretesting, the multiprobe baseline began. During the first baseline session, all three students received a baseline probe. Martin then received a baseline probe on the subsequent session, while the remaining two students received no probes or instruction. When Martin received a third baseline probe, Omar and Antonio received another baseline probe. In the next session, only Martin transitioned to the instructional phase, and only Omar received another baseline probe. When Omar received the third consecutive baseline probe, Antonio also received another baseline probe. Subsequently,

Omar entered the instructional phase, and Antonio received two more consecutive baseline probes before transitioning to the instructional phase.

Instructional Phase

The shared reading instruction occurred daily for 5 weeks and followed a five-day instructional sequence. The research team randomly selected the order in which books were used during the instructional phase. One informational book was read aloud for two consecutive instructional sessions (Days 1 and 2), and the three identified vocabulary words from the book were taught during the shared reading on both days. On Days 3 and 4, the shared reading was conducted with a new book and its three vocabulary words. Thus, a total of two informational books and six vocabulary words were taught per week.

Session probes (described in [researcher-developed assessments](#)) were administered on Day 5 of each week. None of the three students was absent from a scheduled session, so the instructional sequence was never disrupted.

Throughout all sessions, the instructor followed a lesson protocol (see Fig. 1) to ensure fidelity of implementation. The lesson protocol reminded the instructor to introduce the book before reading, explicitly teach target vocabulary words, and ask students to connect the target words to real-life experiences. The sticky notes inserted in each book (see section on Materials) included a lesson script containing the storybook sentences, definitions, synonyms of the three target vocabulary words, and an explanation of how to use each word in a context different from the one in which the word appeared in the book.

Posttest and Maintenance Phase

A maintenance probe was individually administered to each student one week after the student completed all instruction and with no practice opportunities in between ending shared reading and taking the final probe. Students' scores were used to determine if students retained knowledge of the taught vocabulary.

Treatment Fidelity and Documentation of Other Instruction

All instructional sessions were audio recorded, and an independent coder was trained to monitor treatment fidelity using a protocol developed by the research team. Technology issues rendered nine audio files unusable, so 51 of the 60 total sessions (20 instructional sessions per student $\times$ 3 students) were reviewed for treatment fidelity. Thirty-seven files were coded a second time by a research team member to establish the reliability of the independent coder. Inter-rater

Shared Reading Implementation Checklist	
Student:	Book Title:
Lesson Components	
☐	Introduce the storybook. Present the title of the book and describes the objective of the shared reading lesson. <i>“Today, we are going to read a book about science. The title of the book is [Title]. As we read, we will stop to discuss new science vocabulary words.”</i>
☐	Read the assigned storybook aloud to student from start to finish.
☐	Introduce Target Vocabulary Word #1. Use the information on the sticky note attached to the storybook page. ☐ Repeat the Storybook Sentence. ☐ Provide Definition to the Vocabulary Word. ☐ Provide Supportive Context.
☐	Ask student to relate target vocabulary word #1 to a real-life experience. For example, <i>“What is the weather like you where you live?”</i> or <i>“Where have you seen animals with fins?”</i> or <i>“What kind of tools have you used before?”</i>
☐	Introduce Target Vocabulary Word #2. Use the information on the sticky note attached to the storybook page. ☐ Repeat the Storybook Sentence. ☐ Provide Definition to the Vocabulary Word. ☐ Provide Supportive Context.
☐	Ask student to relate target vocabulary word #2 to a real-life experience. For example, <i>“What is the weather like you where you live?”</i> or <i>“Where have you seen animals with fins?”</i> or <i>“What kind of tools have you used before?”</i>
☐	Introduce Target Vocabulary Word #3. Use the information on the sticky note attached to the storybook page. ☐ Repeat the Storybook Sentence. ☐ Provide Definition to the Vocabulary Word. ☐ Provide Supportive Context.
☐	Ask student to relate target vocabulary word #3 to a real-life experience. For example, <i>“What is the weather like you where you live?”</i> or <i>“Where have you seen animals with fins?”</i> or <i>“What kind of tools have you used before?”</i>

Fig. 1 Interventionist’s fidelity of implementation protocol

reliability of the two coders was 93%, and all discrepancies were resolved in [discussion](#). The teacher’s fidelity ranged from 81 to 100%, depending upon the criterion, with an average fidelity of 95%. The lowest agreement, 81%, occurred on the step requiring the teacher to ask a question about the vocabulary word that would help the student relate the word to something meaningful in his life. Because this had to be tailored to each student, this was the only step not scripted for the teacher. Across the scripted steps of the instruction, the instructor demonstrated 99% overall adherence to the protocol.

To increase confidence that any improvement in students’ knowledge of the targeted vocabulary words could be attributed to their participation in the supplemental instruction, the research team documented other science instruction that

students received at school over the course of this study. Students studied two science topics in the general education classroom: trees and weather. Science instruction included hands-on activities (e.g., tracing and sorting leaves and creating wind socks to measure the wind directionality), listening to the teacher read books aloud, or watching videos related to that day’s science instruction. There was limited overlap in the vocabulary and science content between the shared reading instruction and science instruction in the general education classroom. The only vocabulary word overlap was the word *weather*, and there was no overlap in the read aloud books. The frequency of science instruction in the general education classroom varied each week. Students received classroom science instruction every day during the first week of the experimental shared reading sessions.

However, science instruction was reduced to three days during week 2, two days during week 3, one day during week 4, and zero days in the remaining week and maintenance phase of the shared reading instruction.

Data Analysis

Visual analysis was used to determine the trend, level, variability of the data range, immediacy of effect, and the percentage of nonoverlapping data points (PND) between the baseline and instructional phases (Scruggs & Mastropieri, 2013). This is considered the gold standard of evaluating single case research data (Kratochwill et al., 2013). In addition, the effect size was calculated using Tau-*U*, which accounts for phase trends and the nonoverlap between phases (Parker et al., 2011).

Social Validity

Social validity was addressed through questionnaires designed specifically for the students, teacher, and caregivers of the students to gauge the utility and feasibility of the virtually-delivered shared reading and vocabulary instruction. At the end of the study, a member of the research team individually administered the questionnaire orally to all three students and the teacher via videoconferencing. One caregiver of each student completed a digital questionnaire independently.

Results

Students' performance on the standardized tests of vocabulary knowledge administered at pretest revealed that students' expressive vocabulary skills were weaker than their receptive vocabulary skills. Omar and Antonio scored in the 30th and 45th percentile, respectively, on the EVT-III, and Martin scored in the 77th percentile. On the PPVT-V, Martin and Antonio scored in the 88th and 84th percentile, respectively, and Omar scored in the 58th percentile. Thus, all students were performing in the average range.

In addition to determining students' general vocabulary knowledge prior to beginning instruction, students received multiple baseline probes on five randomly selected words from the 30 targeted vocabulary words. They also were tested weekly during the instructional phase (five randomly selected words of the six taught that week), and in maintenance (five randomly selected words of the 30 total). Figure 2 represents the number of words defined correctly on each vocabulary probe for Martin, Omar, and Antonio. The x-axis presents the vocabulary probes by phase and shared reading session; the y-axis presents the score for each probe.

All three students demonstrated an immediate improvement in level of performance on the vocabulary probes and maintained their vocabulary knowledge one week after the instruction concluded. However, performance across the instruction was variable, with some baseline overlap.

Martin

The first student to enter the instructional phase had the strongest pretest and baseline vocabulary performance, but his probe scores declined prior to beginning the shared reading instruction, as is desirable for demonstrating a lack of overall knowledge or mastery of the vocabulary. After beginning the shared reading instruction, Martin demonstrated an immediate improvement in his level of performance. In the following three weeks, Martin's scores dropped slightly, which resulted in overlapping data points between the baseline and treatment phases. However, the final two data points (8, 10) showed an upward trend, indicating steady improvement. This was maintained one week after the end of instruction. The variability in Martin's performance was reflected in the PND (50%), but his effect size (Tau-*U* = 0.2222) revealed the overall positive level and trend of data in the instructional and maintenance phases.

Omar

The second student to enter the instruction had the weakest pretest and baseline vocabulary performance, though still in the average range. His probe scores in baseline declined before beginning the shared reading instruction, indicating a lack of science-related vocabulary mastery. Omar demonstrated an immediate improvement in his level of performance when starting the instructional phase, and then his scores declined the following three weeks. Omar's final data point (9) revealed an upward trend and maintained the progress one week after instruction. Similar to Martin, the variability in Omar's performance was reflected in the PND (50%), but his effect size (Tau-*U* = 0.8333) revealed the overall positive level and trend of data in the instructional and maintenance phases.

Antonio

The third student to enter the instruction scored between Omar and Martin on the pretests and baseline probes. His probe scores declined before starting the shared reading instruction, suggesting he also lacked mastery of the science-related vocabulary. After beginning the shared reading instruction, Antonio demonstrated an immediate improvement in performance. Following the first two weeks of instruction, Antonio's scores declined slightly,

Fig. 2 Score for words defined correctly on probes by Martin, Omar, and Antonio

which resulted in his only overlapping data point between the baseline and treatment phases. However, Antonio's final data point (10) showed an upward trend, and this progress was maintained one week following the conclusion of his shared reading instruction. The lower variability in Antonio's data is reflected in his PND (66.7%), and he demonstrated an overall positive effect of the instruction on his science-related vocabulary learning ($\text{Tau-}U=0.933$).

Social Validity

As shown by the comments in Table 1, none of the students suggested changing anything about the shared reading instruction, and all students reported the most enjoyable part was reading books about science, specifically animal science. Students stated they would use the science vocabulary words in school and other supportive contexts, as well as to communicate with peers.

The teacher reported that she had implemented read alouds to teach general vocabulary words in her classroom; however, after participating in this study, she expressed the

Table 1 Student social validity questionnaire

Question	Student Response
What did you enjoy the most about the book reading lessons?	<p>Martin: “I liked the books that she picked because they were about nature. I liked the first one the best. It was about animals. At the end, it told us that humans are animals to other animals too. I loved getting to share about Mrs. Anna and getting to share about me. I also liked the books.”</p> <p>Omar: “Because there were pictures. I saw like a tiger one. I liked learning about animals—elephants and bunnies.”</p> <p>Antonio: “Getting to learn stuff like there is cold deserts.”</p>
Is there anything you did not like about the book reading lessons?	<p>Martin: “Nope”</p> <p>Omar: “No”</p> <p>Antonio: “I knew a bunch of stuff that I was learning.”</p>
Can you think of some words that were hard for you to learn?	<p>Martin: “I can’t remember what the words were.”</p> <p>Omar: “No”</p> <p>Antonio: “There wasn’t.”</p>
Which words did you learn that you think you will use again? When do you think you will use these words?	<p>Martin: “I think soon I might learn about Arctic in the winter. So, I’m going to use a lot of words about the winter. I might use a sentence about the winter. Polar bears live in the winter. I think I will use the words when I learn at school.”</p> <p>Omar: “I think I will use these words at school and at the zoo.”</p> <p>Antonio: “When I ask my friend, Cade, to come over to build something, I will tell him to bring his <i>tools</i>.”</p>

importance of reading informational books to teach science vocabulary words. She planned to incorporate similar shared reading instruction into her literacy routine. When asked about ways to improve the shared reading, the teacher suggested she would be more intentional about the order books were read so that words reoccur in successive books. The teacher also recommended asking more open-ended questions and inviting students to provide a word’s supportive context on the second day of book reading.

The student participants’ caregivers all reported that they liked how their children received additional one-to-one shared reading instruction and opportunities to read science books. Moreover, they acknowledged that their children used the vocabulary words in daily conversations and expressed how valuable it would be for their children to participate in similar shared reading instruction at school.

Discussion

Implementing science instruction in kindergarten classrooms provides a foundation of scientific knowledge and an introduction to informational texts that students will read throughout school (Wright & Domke, 2019). Therefore, this study explored the effects of virtual shared reading instruction conducted with science-related informational books on

kindergarten students’ academic vocabulary development. Traditionally, there has been limited science instruction implemented in early elementary classrooms (Wright & Gotwals, 2017) and an overreliance on incidental rather than explicit approaches to teaching academic vocabulary (Beck & McKeown, 2007; Neuman et al., 2011).

These circumstances might be exacerbated by the limitations of remote learning during the COVID-19 pandemic. Although students in the current study received about 90 min of typical reading instruction per day, it is not known how much of that time—if any—was devoted to directly teaching academic or content-specific words during online learning. Given that the students participated in the same amount of science instruction in a virtual classroom as their peers in the face-to-face classroom (about 20 min per lesson × 11 lessons during the time of the study), they did not receive as much daily exposure to science concepts or explicit instruction in science-related vocabulary as they did during the shared reading instruction. Thus, it is possible that classroom social-distancing restrictions and remote learning may have decreased students’ opportunities for frequent exposures to academic language during conversations with their classroom teacher (Oracy All-Party Parliamentary Group, 2020). Results of the purposeful teaching of science content and related words done in this study indicated the virtual shared reading demonstrated positive effects on kindergarten

students' science-related vocabulary learning, though Omar and Antonio had considerably higher magnitude Tau-*U* values (0.833 and 0.933, respectively) than Martin (Tau-*U* = 0.222). All three students demonstrated a decline in baseline probe performance prior to beginning the shared reading instruction, an immediate improvement in their level of performance after starting the instructional phase, and a maintenance of their vocabulary knowledge one week after the end of the shared reading sessions.

Nevertheless, students' performance across the shared reading sessions was variable with students all demonstrating a marked decline on the probe administered in the third week. All students missed the same two words (i.e., *harsh*, *adapt*) that week. A similar pattern was detected during week four as two of the three students declined on the vocabulary assessment, missing the same two words (i.e., *bogs*, *soil*). Because the instructional phase probes were specific to the words taught that week, it is possible there was something about the informational books used in weeks 3 and 4 or the science content they contained that made those vocabulary words more challenging for students. It is known that background knowledge is related to vocabulary word acquisition (Ahmed et al., 2016; Cromley et al., 2010), so it is possible that the students in this study had limited familiarity with the scientific concepts about deserts and wetlands. These were not geographical features of the area in which student participants lived.

We also noted that the higher the pretest knowledge among the three student participants, the more variability in performance demonstrated. This may indicate that the instructional phase performance of Martin, who had the highest pretest scores, may have been reflective of when he did or did not have background knowledge of the words or science concepts, rather than the influence of the instruction. However, the two students with relatively lower pretest scores could not rely on preexisting knowledge of the words to the same extent. It could be that when performance was more consistently dependent upon the instruction, students demonstrated less variability in their probe scores.

This would be consistent with previous research suggesting that students with lower vocabulary skills may benefit more from explicit vocabulary instruction (Justice et al., 2005; Pollard-Durodola et al., 2011). Given the greater effect sizes for the students who had lower pretest knowledge and more stability in their performance while receiving instruction, future research with larger sample sizes might explore whether shared reading instruction might contribute to closing the gap between initially lower performing kindergarteners and their higher knowledge peers. Furthermore, given the influence of language and literacy on the learning of science content (Reed et al., 2017), early exposure to science vocabulary words during shared reading instruction may help students with poor vocabulary skills build the background knowledge they need to communicate scientific concepts and comprehend

science-related informational texts in later school years (Fang, 2012; Nagy & Townsend, 2012).

Limitations and Directions for Future Research

The kindergarteners in this study had pretest expressive and receptive vocabulary abilities in the average range. These are not the kinds of students about whom researchers have expressed concern or considered a priority for building lexical knowledge (Catts et al., 2008). Although the participants in the present study still demonstrated improvements in their science-related vocabulary performance, future research should examine the impact of virtual shared reading and vocabulary instruction on the learning of students with below average abilities who are at risk for later reading or academic failure (Neuman & Kaefer, 2018).

The shared reading in this study was delivered one-on-one in a virtual setting due to an increase in infection rates of COVID-19 in the community in which the participants lived. During the pandemic, remote learning was used more frequently than is typical, but that instruction did not necessarily occur individually. Martin, Omar, and Antonio's outcomes might have been different if the sessions had been held in small groups, so additional research on group sizes is warranted.

The instructor was able to maintain strong fidelity to the scripted instructional procedures (99% on average), but she had lower fidelity (81%) to the unscripted step of asking a question about each word to personally connect it to a student's experiences or interests. Lower treatment integrity can be a sign that the experimental instruction is not feasible for teachers to implement (Lee et al., 2009). The virtual shared reading instruction was delivered as a supplement to students' typical remote learning, and the instructor was not the students' typical classroom teacher. Therefore, her fidelity may suggest it was not feasible to extemporaneously create tailored questions for students with whom she had fewer daily interactions than a typical classroom teacher. In future studies, instructors might be offered choices of real-world application questions for each vocabulary word.

We observed science instruction during the participants' regular school day to ensure minimum overlap between our vocabulary instruction with informational science books and students' typically occurring science instruction. However, it is possible that students might have been exposed to the targeted words during other instructional blocks (e.g., reading, social studies). We chose not to observe the reading block because 77% of our vocabulary words were targeted for a science-specific definition,

and teacher read alouds of informational science books occurred during the typical science instruction. Coupled with previous findings that very little time in early elementary grades is dedicated to science vocabulary (Wright & Gotwals, 2017), we reasoned that—particularly during the instructional constraints of the COVID-19 pandemic—the greatest potential for overlap with our intervention’s explicit vocabulary instruction would be during the science instructional block. Future research might consider observing different parts of the school day or activities outside of the school day (e.g., daycare, home) to document any cumulative exposure kindergarteners might have to science vocabulary.

Implications

Consistent with previous research (Mantzicopoulos & Patrick, 2011; Pollard-Durodola et al., 2011), the results of this study suggest that young children’s learning of science-related vocabulary may be fostered by explicitly teaching new words with understandable definitions, explanations of the words in the context of a book being read, and offering examples or questions to relate the word to other contexts. These procedures provided students with meaningful information about the word and allowed them opportunities to talk about the word and how it related to their lives. Moreover our findings suggest that informational science trade books are a valuable resource for teaching science content to young children, which is encouraging for early childhood educators who may lack curricular materials to teach science instruction. Thus, early childhood teachers may benefit from professional development on delivering science instruction during shared reading of informational science trade books.

In addition, student learning of academic vocabulary may be enhanced by conducting shared reading with science-related informational trade books commonly used in kindergarten classrooms. The context and illustrations of the books were evaluated for the support they provided for learning the content and vocabulary, and the teacher used book illustrations to ask open-ended questions that related the new words to students’ lives. Visual representations of words act as a conversation starter and may improve students’ understanding of a new word’s meaning (Martinez & Harmon, 2012).

Finally, instruction in the present study was designed to offer students repeated exposures to the science words. Previous research has established that new words are learned iteratively through multiple opportunities to encounter and work with the words (Beck et al., 2013; Hadley & Dickinson, 2019). In each of the five weeks of the shared reading instruction, the teacher in this study read an assigned book on two consecutive days, repeating the explicit procedures during both book readings. This distributed practice may

afford students the chance to consolidate their learning and improve the likelihood that knowledge of the words would be maintained (Henderson et al., 2012).

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