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The relationship between media type and vocabulary learning in a cross age peer-learning program for linguistically diverse elementary school students

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ABSTRACT

The goal of the present study was to compare children's word learning through print text, video, and electronic text in the context of a cross-age peer-learning program implemented in linguistically diverse kindergarten and fourth grade classrooms that included English Learners (ELs) and their non-EL peers. Children were assessed at pre- and post-test on measures of receptive and expressive vocabulary knowledge. Findings showed effects of media type on word learning. Effects differed across grades (i.e., kindergarten and fourth grade, language background (i.e., non-EL and EL), and knowledge types (i.e., receptive and expressive). In kindergarten, results suggest that video may be more helpful than electronic texts for supporting receptive and expressive vocabulary, and video may be more helpful than both print and electronic texts for supporting the expressive vocabulary of ELs. In fourth grade, results suggest that video and electronic texts may be more helpful than print texts for supporting expressive vocabulary for non-ELs but not for ELs.

0. Introduction

Vocabulary knowledge is a key to comprehension (Kintsch, 2013). Prior research indicates that in order to have moderate comprehension of a text, a person needs to understand 95–98% of the words in the text (Hu & Nation, 2000; Lauffer, 1989; Schmitt, Xiangying, & Grabe, 2011). Students with limited vocabulary knowledge may have more difficulty comprehending text than their peers with more advanced vocabulary knowledge, and this may affect students' success throughout school and beyond (Cunningham & Stanovich, 1997). While supporting vocabulary development is important for all students, it may be particularly important for English Learners (ELs; Baker, Lesaux, Jayanthi, Dimino, Proctor, Morris, Gersten, Haymond, Kieffer, Linan-Thompson, & Newman-Gonchar, 2014). Limited knowledge of vocabulary in English, the typical language of instruction in U.S. schools, could be a major barrier for many ELs who speak a language other than English at home (Mancilla- Martinez & Lesaux, 2011; Silverman et al., 2015).

Two critical time periods for addressing vocabulary may be upon school entry when students are first exposed to academic language and during the transition from lower to upper elementary school when expectations that students learn through reading tend to increase (Beck & McKeown, 2007; Chall & Jacobs, 2003). In fact, research on vocabulary instruction during these time periods suggests that, given research-based instruction, students with limited vocabulary may even begin to catch up to their peers with more advanced vocabulary (Biemiller & Boote, 2006; Carlo et al., 2004; Crevevoeur, Coyne, & McCoach, 2014; Silverman & Hines, 2009).

Traditionally, vocabulary instruction is connected to the books teachers read aloud to students or the books students read to themselves. Typically, teachers introduce words prior to reading through definitions and examples as well as pictures and gestures (Beck & McKeown, 2007; Biemiller & Boote, 2006). Teachers may also target words in text through embedded instruction, where words are explained through in situ parenthetical explanations (August, Artzi, & Barr, 2016; Coyne, McCoach, & Kapp, 2007). Often teachers prompt students to discuss or review words after reading through whole class, small group, or partner conversations as well (Beck & McKeown, 2007; Coyne et al., 2007; Silverman & Crandell, 2010). For ELs, instruction might include providing visuals or actions to facilitate word learning or highlighting cognates and providing translation for definitions (Carlo et al., 2004; Silverman, 2007a, 2007b).

While there is a long history of using books as a context for introducing students to vocabulary, recent evidence has emerged that using videos and electronic texts might provide equally or even more rich contexts for promoting vocabulary, particularly for ELs (Silverman & Hines, 2009; Uchikoshi, 2006; Verhallen, Bus, & de Jong, 2006).

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However, there is limited research comparing the effect of different media types on children's word learning for ELs and non-ELs across grade levels in elementary school, and results across studies have differed according to whether vocabulary was assessed through receptive or expressive measures. Through the implementation of a cross-age peer-learning program set in linguistically diverse kindergarten and fourth grade classrooms that included print text, video, and electronic text, we had the opportunity to compare children's receptive and expressive word learning through different types of media. Our goal in the present study is to add to the emerging research base on the use of different media types for supporting the receptive and expressive vocabulary of ELs and non-ELs at different grade levels.

1. Theoretical framework

The potential benefit of multimedia for supporting children's word learning stems from Dual Coding Theory (Paivio, 1986). This theory suggests that information is processed through two separate pathways in the brain: one verbal and one nonverbal. Further, the theory suggests that information that is encoded both verbally and nonverbally could be learned more thoroughly than information encoded through only one of these modalities because learners could take advantage of both processing systems as they acquire the new information. While print text includes both words and pictures, the addition of audio and action in video and interactive features in electronic texts could, then, make these types of texts more rich for word learning, particularly for ELs who may have more difficulty accessing verbal definitions and explanations in English than their non-EL peers (Silverman & Hines, 2009).

Building on Dual Coding Theory as well as advances in research on how humans learn, a major tenant of Universal Design for Learning (UDL; Meyer, Rose, & Gordan, 2014), a framework for optimizing teaching and learning for all learners, is that educators should provide students with multiple means of representation to support learning. According to UDL, presenting information in different ways (e.g., using both auditory and visual representations) makes that information optimally accessible for different learners (e.g., ELs and non-ELs). A key recommendation in the articulation of UDL is to illustrate information through multiple media. "Providing content in multiple media supports those who require it (essential for some) but also supplies a rich cognitive learning environment where varied options and interactivity create a more nuanced experience, enabling learners to explore the content from multiple points of view (good for all)" (p. 54; Meyer et al., 2014).

While these theories support the use of multimedia for supporting children's word learning, there is some theoretical basis for considering the limitations of multimedia as well. For example, Cognitive Load Theory (van Merrienboer & Sweller, 2005) suggests that having too much input could tax working memory and inhibit learning. Multimedia features like animation and interactives could, arguably, present children with too much information to be able to learn from the context. Mayer and Moreno (2003) and Shamir, Korat, and Fellah (2012) suggest that the problem could be particularly acute when there is incoherence between the content of the multimedia and the multimedia features that are meant to enhance the comprehension. The strain on cognitive load could, theoretically, be particularly acute for ELs who have to coordinate information from different media in their non-native language (Takacs, Swart, & Bus, 2015), though ELs have, in some studies, been shown to have higher executive functioning skills than non-ELs (e.g., Bialystok, 2011; Carlson & Meltzoff, 2008). Therefore, additional research is needed on the role of different media in promoting vocabulary for ELs versus non-ELs.

Developmentally, there could be different effects of multimedia on vocabulary learning for younger and older students. Children's executive function skills including working memory, inhibition, and flexibility increase over time (Best & Miller, 2010). While younger children may be overwhelmed by various sources of information and not be able to integrate information across these various sources, older children might actually be able to take advantage of the various ways information is presented to develop deeper understanding of content. Particularly features such as interactives may be easier for older rather than younger children to use productively. Thus, research is needed on whether the effect of multimedia on vocabulary differs by grade.

Furthermore, effects of multimedia on vocabulary learning could depend on whether receptive or expressive vocabulary knowledge is considered. Theoretically, receptive vocabulary knowledge, which includes being able to recognize words and word meanings, represents a shallower level of word knowledge than expressive vocabulary knowledge, which involves being able to use words accurately in context (Beck, McKeown, & Omanson, 1987). Thus, while receptive word knowledge may be acquired through relatively limited exposure to words, expressive word knowledge may require more robust contexts such as those presented in video and electronic text versus print text. Verhallen and Bus (2011) suggest that while different types of media may have no differential effect on receptive word knowledge, the added information about words provided in multimedia may support expressive word knowledge more than print media alone. Interestingly, work by these authors on the effects of multimedia showed that it was not uncommon for word knowledge to be captured on a receptive or an expressive task but not both at the same time, suggesting that receptive and expressive measures may tap different aspects of word knowledge all together. Thus, research is needed on the role of multimedia in supporting word learning on receptive and expressive tasks.

2. Background

The benefits of exposure to traditional texts for vocabulary learning have been well-established (Baker et al., 2014; Hairrell, Rupley, & Simmons, 2011; Mol, Bus, De Jong, & Smeets, 2008; Swanson et al., 2011). Traditional texts provide rich context for vocabulary learning, and parents and teachers can use the pictures and words in traditional texts to explain new words. Studies have shown that children in both lower and upper elementary school learn vocabulary in the context of reading or listening to traditional texts (e.g., August et al., 2016; Beck & McKeown, 2007; Carlo et al., 2004; Coyne et al., 2007; Nelson, Vadasy, & Sanders, 2011; Penno, Wilkinson, & Moore, 2002; Silverman, 2007a, 2007b). For example, Biemiller and Boote (2006) found positive, significant, and substantial effects of repeated book reading and word explanations on expressive vocabulary knowledge in a linguistically diverse sample of students in kindergarten through second grade. For another example, Solis, Scammacca, Barth, and Roberts (2017) found 4th graders with low comprehension ability (31% EL) who participated in a text-based vocabulary and reading intervention made statistically significant gains on a researcher-developed receptive measure of reading and vocabulary compared with students in the comparison condition. In fact, systematic reviews of the literature provide evidence for the positive effects of listening to or reading traditional print texts on receptive and expressive vocabulary learning (Mol & Bus, 2011; Swanson et al., 2011).

In the recent past, there has also been a growing body of research on the use of video to support children's word learning. For example, studying the effect of preschool television viewing, Wright, Huston, Murphy, and St. Peters, Piaton, & Scantlin (2001) found a strong correlation between viewing of educational programs and vocabulary. Additionally, Uchikoshi (2006) found that bilingual kindergarteners who watched specific educational programs at home grew faster in vocabulary than their peers who did not watch these shows at home. In fact, some school-based interventions now include video to support vocabulary instruction (e.g., Chambers, Cheung, Madden, Slavin, & Gifford, 2006; Neuman, Newman, & Dwyer, 2011). For example, Silverman and Hines (2009) compared the vocabulary learning of children in pre-kindergarten through second grade under two conditions: traditional print text reading and print text reading with the addition of video. These researchers found that there was no effect

between the conditions for monolingual English-speaking students, but the addition of video was particularly beneficial for the receptive vocabulary learning of English learners (ELs) in their sample. Several years later, Silverman (2013) conducted a study in classrooms with substantial numbers of children from low-income and EL backgrounds to compare kindergarten children's word learning through print text versus video. Results showed no difference in vocabulary learning between the video and print text conditions on receptive or expressive tasks. Silverman (2013) noted, however, that instruction was minimal in the study to test for the role of media. Continued research is needed to explore the role of different media in vocabulary learning when used in the context of instruction.

Though research on the effect of video on vocabulary learning in upper elementary school is limited, research by Xin and Rieth (2001) suggests that video may be helpful for word learning in these grades. These researchers examined vocabulary instruction in special education resource classrooms with 76 4th–6th grade students. They investigated effects for word learning through print text versus video. Results indicated a positive effect of the video over print on word learning on an expressive but not a receptive vocabulary task. In 2014, Lowman published a study comparing podcasts (audio files) and vodcasts (video files) as media for supporting the word learning of students in grades 4 and 6. Results showed that students in the vodcast group learned significantly more words than students in the podcast group according to both receptive and expressive word knowledge measures. In a study published in 2015, Lowman and Dressler compared print only and print plus video conditions for supporting the word learning of 5th and 6th grade children with Specific Language Impairment. Findings indicated positive and significant effects of the print plus video over the print only condition on students' receptive and expressive word learning.

In addition to research on video as a support for word learning, there has been substantial research on the effect of electronic texts on vocabulary. Some of this research suggests that the use of e-books is as effective as the use of read alouds of print texts for supporting word learning. For example, Korat and Shamir (2007) compared the effects of listening to adults read a printed text versus listening to an electronic book on kindergarten children's vocabulary learning. These researchers found that children in both intervention groups improved in receptive vocabulary knowledge and both gained more than a control group, but children in the two intervention groups did not differ in receptive vocabulary learning. Other research suggests that the use of e-books could be even more effective than using read alouds of print texts to support word learning. For example, Smeets and Bus (2015) compared the effects of static e-books, animated e-books, and interactive animated e-books on kindergarten word learning as assessed via a task that captured both receptive and expressive word knowledge. Children in all three conditions learned more vocabulary than children in a control group. Findings suggested that children learned the most via interactive animated e-books followed by (noninteractive) animated e-books and then static e-books. Findings also suggested that e-books had no effect (positive or negative) on story comprehension.

With respect to upper elementary school learners, Proctor, Dalton, and Grisham (2007) explored fourth grade students' use of a digital reading environment and found that students' use of multimedia features such as hyperlinked definitions and written, audio, and pictorial information was related to gains in students' receptive vocabulary knowledge as measured via a standardized assessment. In a subsequent study, Proctor et al. (2011) investigated the effects of a web-based vocabulary program on the vocabulary learning of 5th grade English-speaking and Spanish–English-speaking students. The electronic texts in the program targeted 40 words and included embedded supports (e.g., definitions, translations, a multimedia glossary). Compared to students who did not participate in the program, students who did participate in the program grew more in expressive (though not receptive) knowledge of target words and showed greater gains on a standardized measure of receptive vocabulary knowledge.

Recently, Takacs et al. (2015) conducted a meta-analysis of 43 studies comparing the effects of technology-enhanced texts to traditional print text reading on young children's vocabulary. Participants in the studies were enrolled in preschool or elementary school. These authors found positive effects of technology-enhanced texts on expressive vocabulary ($g+ = 0.20$) and story comprehension ($g + = 0.17$). There was no significant effect on receptive vocabulary, though the authors speculate that this may be related to ceiling effects on receptive measures across studies. Further analyses suggested that "the advantage of multimedia-enhanced stories was not due to the addition of illustrations but to features that can only be realized with the help of multimedia (e.g., animated pictures, sounds and music)" and "children from disadvantaged family environments (low SES and/or immigrant, bilingual families) benefited most from multimedia" (p. 728). However, additional analyses suggested that interactive features such as hotspots, games, and dictionaries were detrimental to student learning, especially for children at risk for experiencing language and literacy difficulty later in school. Findings from this meta-analysis echo those from a synthesis by Zucker, Moody, and McKenna (2009) who, in a review of the effects of electronic books on language and literacy outcomes in pre-kindergarten through fifth grade, found positive (small to medium) effects of e-books on comprehension-related outcomes including vocabulary and language skills.

Despite this substantial research base, there are few studies that directly compare the effects of print text, video, and electronic text in the same study, holding all other aspects of instruction constant, and there are no studies that make this comparison with lower and upper elementary school students, ELs and non-ELs, and receptive and expressive vocabulary measures. Given the critical role of vocabulary in comprehension and success in school (Kintsch, 2013) and the growing prevalence of technology in education (Herold, 2016), it is important to make these comparisons to inform research and practice.

3. The present study

Given the need for research to explore the effects of different types of media (i.e., print text, video, and electronic text) on children's vocabulary learning, we conducted a secondary analysis of data from a study of a cross-age peer learning program that included these three media types. The cross-age peer learning program was conducted with kindergarteners and fourth graders in linguistically diverse schools. The primary analysis was focused on the effect of the cross-age peer learning program on students' vocabulary and comprehension by comparing outcomes for students who did and did not participate in the program. While systematically incorporating different types of media was a design feature of the cross-age peer learning program, the primary analysis did not include any investigation of these media types. In fact, given that the primary analysis included measures such as general vocabulary knowledge and reading comprehension that could not be teased apart according to media type, it would have made the primary analysis confusing and unwieldy to incorporate media type. Thus, a secondary analysis focused just on media type using data that can be teased apart to examine differential effects according to this factor is warranted, especially considering that it can add to the research base on the role of different media types in vocabulary learning.

Given the previously reviewed literature, the following overarching research question guided this secondary analysis: *What are the relative effects of different media types (*i.e.*, print, video, and electronic) on kindergarten and fourth grade word learning?* Additional questions included the following: (a) *Do the relative effects of different media types differ for kindergarteners and fourth graders?* (b) *Do the relative effects of different media types differ for non-ELs and ELs?* (c) *Do the relative effects of different media types differ on receptive and expressive tasks?* Based on theory and research discussed above, we hypothesized that the affordances of video and electronic media would benefit word learning for both kindergarteners and fourth graders but effects may be greater for fourth

graders since they may be able to more readily coordinate the verbal and nonverbal information provided in these media types. We also hypothesized that ELs would benefit from video and electronic media more than non-ELs because the nonverbal information would be especially helpful to them as they learned new words. Finally, we hypothesized that positive effects of video and electronic media would be more robust on expressive rather than receptive tasks because expressive tasks may be more sensitive to the depth of word learning facilitated by multimedia.

4. Method

The goal of the present study, conducted within the context of a larger study on the effects of cross-age peer learning on vocabulary and comprehension, was to compare kindergarten and fourth grade vocabulary learning via three different types of media: print text, video, and electronic text. In order to meet this objective, we analyzed whether the effect of condition (i.e., intervention or comparison) differed by the different types of media used in the cross-age peer learning program. Condition was a between-subjects factor and media type was a within-subjects factor in that all students in the intervention experienced all three media types.

4.1. Context

The cross-age peer learning program implemented in this study, the Martha's True Stories (MTS) Buddies Program (Silverman et al., 2017), was based on reading buddies programs that are implemented widely across the U.S (Theurer & Schmidt, 2008), though the MTS Buddies Program included greater emphasis on reading informational text, explicit instruction on vocabulary and reading comprehension strategies, and explicit guidance for peer interaction than provided in typical reading buddies programs. The program, which paired kindergarten and fourth grade students to read texts or watch videos together, was organized into four thematic units: Caring for the Environment, Technology All Around Us, Amazing Inventions, and Everyday Measurement. Each unit included one print text, one video, and one electronic text. The program was implemented for 14 weeks in 6 kindergarten ("little buddy") and 6 fourth grade ("big buddy") classrooms. An additional 6 kindergarten and 6 fourth grade "business as usual" classrooms served in the comparison condition.

Each week, students in the intervention condition participated in one teacher-led lesson with their homeroom teacher and one cross-age peer learning or "buddy" session. The teacher-led lesson in kindergarten (30 min) focused on previewing the content and vocabulary that little buddies would encounter with their fourth grade big buddies in a subsequent lesson. The teacher-led lesson in fourth grade (45 min) included explicit instruction on content and vocabulary, practice with same-age peers to support comprehension and word learning when reading a text or watching a video with their little buddies, and reviewing steps to follow in the cross-age peer learning session. When big buddies and little buddies met, big buddies guided little buddies during text reading or video watching, reviewed target vocabulary words, and supported little buddies in extension activities that typically involved drawing or writing. The lesson format was consistent for all media and text types (print text, video, and electronic text). Fidelity of program implementation was measured via a checklist used during four observations in classrooms using the MTS Buddies Program. Results indicated that 91.6% of essential components of the intervention were implemented.

Students in the comparison condition participated in regularly scheduled classroom activities. In kindergarten, these activities included mainly teacher-led read alouds of texts of the teachers' choosing. In fourth grade, these activities included mainly teacher-led whole group reading and discussion of text from a basal anthology. Teachers and students in the comparison condition were not provided with any materials from the MTS Buddies Program, and observations of comparison classrooms verified that students in the comparison condition were not exposed to program texts and words. Thus, it was not surprising that kindergarteners and fourth graders in the intervention condition learned more target words than students in the comparison condition. (Other findings from the larger study showed that kindergarteners in the intervention made greater gains than kindergarteners in the comparison in general vocabulary knowledge and fourth graders in the intervention made greater gains than fourth graders in the comparison in general comprehension over the course of the study.) The main question in the present study was whether the effect of the intervention on kindergarten and fourth grade target vocabulary learning differed according to the type of media in which the words were embedded: print text, video, or electronic text.

4.2. Participants

In this study, teachers were assigned to condition. Teachers in the intervention condition were trained to deliver the teacher-led lessons and facilitate the buddy sessions. All teachers were certified and considered "highly qualified" by the school district. After assigning teachers to condition, we sent home forms asking parents for permission to assess their children. We received permission to assess 65% of the kindergartners and 71% of the fourth graders in the classrooms in the study. All students in the intervention group classrooms participated in the program, but we only assessed those students for whom we had permission.

The final student sample included 196 kindergartners (i.e., 106 in intervention and 90 in comparison) and 239 fourth graders (i.e., 131 in intervention and 108 in comparison). Of the students in the final sample, 63% were Hispanic, 25% were Black, 4% were White, and 5% were classified as Other Race. We were unable to obtain race/ethnicity data on 3% of the students. Overall, 83% of the sample received free and reduced price lunch, an indicator of low socioeconomic status. In kindergarten, 48% in the intervention and 51% in the comparison group were designated by the school district as Limited English Proficient (LEP). In fourth grade, 18% in the intervention and 23% in the comparison group were designated LEP. We refer to students designated as LEP by the district as ELs.

4.3. Content

In the study, content was delivered through three different types of media. All content was developed by WGBH Boston (a Public Broadcasting Service affiliate), in consultation with the first author, to focus specifically on supporting vocabulary learning. Each of these texts was part of the *Martha Speaks True Stories* (MTS) suite (http://pbskids.org/martha/stories/truestories/), based on the *Martha Speaks* books by Susan Meddaugh and the television show by WGBH Boston about the adventures of a talking dog named Martha and her human and canine friends. While the *Martha Speaks* books and shows target children ages 4–7, the content chosen for the MTS suite is appropriate for both kindergarten and fourth grade, especially considering that kindergarteners were supported by fourth graders to be able to access the content and fourth graders were highly motivated to share the content with the kindergarteners in their role as "big buddies." Note that the MTS Reading Buddies program was developed in a two-year iterative process that involved kindergarten and fourth grade teachers who indicated in interviews and surveys that the content was appropriate for kindergarten listening comprehension and fourth grade reading comprehension. In fact, the texts were developed to intentionally allow for multiple entry points so that some students could learn more basic words and concepts and others could learn more advanced words and concepts through the same materials depending on their present level of knowledge and their engagement in the program.

4.4. Media

Different types of media have different affordances for learning. In general, print media includes text and static illustrations. Often, print media also includes text features such as text boxes with definitions and glossaries. Videos typically do not have text on screen, but they do have audio and dynamic illustrations to show content. Finally, electronic texts include some features of both print and video. Electronic texts typically include text on screen with optional interactives, hyperlinked definitions, and quiz-like games. The media used in the present study reflect typical characteristics of print, video, and electronic texts, respectively. While every effort was made to ensure that content was delivered similarly across media types, there are differences in the way content is inherently delivered across media that were retained in this study. In other words, rather than make content delivery exactly the same across media types, the treatment of the content was allowed to vary according to media type in order to capture the affordances offered by each specific type of media.

The content in the present study was organized into four science, technology, engineering, and math (STEM) themes: Environment, Technology, Inventions, and Measuring. Each theme included one print, one video, and one electronic text. Thus, there were four print texts, four videos, and four electronic texts included in the present study. All content was "hybrid" in that it included factual information within a narrative arc. In the versions that were used in the present study, print text that included text boxes with definitions and a glossary of target words in the back of the text. Videos, which were 11-min each and shown on an overhead projector, did not include text on screen but had dynamic audio and visuals (e.g., character dialogue and action shots) and embedded definitions. For example, when a character used the word litter in the environment theme, the character defined the word saying, "When people litter, that means they just throw their garbage on the ground." Electronic texts, which were accessed via a tablet device, had text-to-speech and included words that could be clicked for pop-up definitions, hot-spots with animations aligned to the content (e.g., when clicking on a hot spot after reading about creatures a beaver pops up out of the ground), brief interactives (e.g., after reading about observing animal habitats, students could move a pair of binoculars around the screen to see objects up close), and a short "quiz" at the end.

In the program, interactive shared reading techniques were used in the context of the cross-age peer learning program where the buddies read together and stopped at points to discuss the text with each other and to ask comprehension questions about the text. If the pairs were watching a video together, the same interactive engagement techniques were used where videos were periodically stopped so the pairs could engage in conversations about the content and video themes. (For more background on this program and teacher involvement see (Peercy, Martin-Beltran, Silverman, & Guthrie, 2015; Peercy, Martin-Beltran, Silverman, & Daniel, 2015; Martin-Beltran, Tigert, Peercy, & Silverman, 2017; Silverman et al., 2017).

4.5. Words

A total of 9 academic words were purposefully embedded in each text used in the MTS Reading Buddies program. Of these, 52 were selected for focus in teacher-led and buddies sessions. Four of these words were thematic words that were discussed across multiple texts. The remaining 48 words that appeared in only one text were used in this study. Of these, 16 words appeared in each media type: print text, video, and electronic text. Words were equated across media type using several systems for comparing words: frequency per million words (the *U* statistic) in the *Educator's Word Frequency Guide* (Zeno, Ivens, Millard, & Duvvuri, 1995), a corpus of texts sampled across content encountered in kindergarten through college; frequency in the Corpus of Contemporary American English (COCA) database of words culled from a wide range of English texts (Davies, 2017); and word level derived from the *Living Word Vocabulary* (LWV; Dale & O'Rourke, 1981) and *Words Worth Teaching* (WWT; Biemiller, 2010). Means (standard deviations) for the *U* statistic from the Educator's word frequency guide across media type were 30.43 (8.48) for paper, 29.51 (8.48) for video, and 43.64 (9.30) for electronic texts. One-way ANOVA suggests no significant differences across media type ($F(2, 45) = 0.43$, $p = .65$). Means (standard deviations) for the COCA were 20,614.19 (6098.07) for paper, 19,512.81 (8282.05) for video, and 19,601.13 (2957.22) for electronic texts. One-way ANOVA suggests no significant differences across media type ($F(2, 45) = 0.01$, $p = .99$). We dichotomized word levels from LWV/WWT into typically known by grade 2 (i.e., lower elementary words) and typically unknown by grade 2 (i.e., upper elementary words). In each media type, there were 8 words categorized as lower elementary and 8 words categorized as upper elementary.

4.6. Measures

We administered both norm-referenced and researcher-developed assessments to evaluate kindergarten and fourth grade vocabulary knowledge. All kindergarten assessments were administered individually, but all fourth-grade assessments were group-administered to reduce testing time. Pre-tests were administered in the fall (i.e., October/November) and post-tests were administered in the spring (i.e., April/May) of the academic year. The time between testing was held constant across intervention and comparison students to ensure that an equal amount of time between pre- and post-test passed between conditions.

4.6.1. Kindergarten assessments

Peabody Picture Vocabulary Test (PPVT). To assess general word knowledge, we administered the PPVT, fourth edition (Dunn & Dunn, 2007). The PPVT is a norm-referenced measure of receptive vocabulary. Students are shown a set of four pictures and given a one-word stimulus. Students are prompted to point to the picture that matches the one-word stimulus. The PPVT has split-half reliability of 0.94 and test-retest reliability of 0.95. We used the PPVT Growth Scale Value (GSV) scores from pre-test as a co-variate in analyses in this study.

Receptive Assessment of Vocabulary - Kindergarten (RAV-K). This researcher developed, curriculum-aligned measure assessed the kindergarten participants' receptive knowledge of 30 words targeted in the intervention. This assessment was modeled after point to picture item types frequently found in vocabulary assessments with this age group (e.g., the Test of Language Development and the Peabody Picture Vocabulary Test). Students were shown four semantically related pictures (e.g., children engaging in different activities around the classroom) and asked to choose the one that best described the target word (e.g., "Which picture shows children constructing?"). Coefficient H, an alternate measure of internal consistency to Cronbach's alpha (Hancock & Mueller, 2001) was 0.87 at pretest and 0.93 at posttest. The correlation between the RAV-K and the PPVT was 0.66 at pretest and 0.72 at posttest.

Expressive Vocabulary Assessment-Kindergarten (EVA-K). This researcher developed curriculum-aligned measure assessed expressive knowledge of 18 words targeted in the intervention. Developed from an item-type reported in Coyne et al. (2007), students were prompted to orally provide the meaning of a target word (e.g., "What does the word evidence mean?"). Administrators asked students one follow-up question per word (e.g., "Tell me anything else you know about the word evidence.") Students' responses were audio-recorded and transcribed. Research assistants (RAs) coded student responses according to a 3-point scale (i.e., 0 points for incorrect or unrelated answers, 1 point for somewhat related words or examples, 2 points for highly related words or examples or partial definitions, and 3 points for complete and accurate definitions). Interrater reliability among the RAs was 0.90 (Cohen's kappa). Coefficient H was 0.97 at pretest and 0.95 at posttest. The correlation between the EVA-K and the PPVT was 0.66 at pretest and

0.68 at posttest.

4.6.2. Fourth grade assessments

Gates MacGinitie Reading Test (GMRT) Vocabulary Subtest. A norm-referenced measure, the GMRT (MacGinitie, MacGinitie, Maria, & Dreyer, 2000) was administered to all fourth graders in the study. On the 20-min vocabulary subtest (GMRT-V), students read a sentence with a word underlined. Then students are presented with four words from which to choose. Students are required to select the choice that could replace the underlined word in the sentence. The Kuder-Richardson Formula-20 (KR-20) internal consistency and test-retest reliability coefficients were above 0.90 in fourth grade. We used the GMRT Growth Scale Value (GSV) for the GMRT-V from pre-test as a covariate for analyses in this study.

Receptive Assessment of Vocabulary – Fourth Grade (RAV-4). This researcher developed curriculum-based measure assessed receptive knowledge of 24 words targeted in this study. The test administrator read all items aloud to students. Each item provided students with a sentence that included a synonym for a target word. Students were asked to select the target word that best matched the synonym. This orally administered assessment consisted of 36 items. Students were asked to choose a word (e.g., "innovated, declined, attempted, or produced") that was analogous to the synonym presented in a sentence (e.g., "He tried to kick the ball into the goal. Which word means tried?"). Questions were Lexiled at the fourth-grade level according to the Lexile Analyzer (MetaMetrics, 2013). Furthermore, distractors were equivalent in frequency, length, and morphological and syntactic construction across items. Coefficient H was 0.94 at pretest and 0.96 at posttest. The correlation between the RAV-4 and the GMRT-V subtest was 0.63 at pretest and 0.63 at posttest.

Expressive Vocabulary Assessment-Fourth Grade (EVA-4). This researcher-developed measure assessed expressive knowledge of 18 words targeted in the intervention. Students were prompted to write the correct meaning for a target word (i.e., "Write one to two sentences to tell what the words below mean."). The administrator read the directions and each word aloud. Members of the research team coded student responses on a 0–3 scale, with 3 being a fully detailed and correct answer. The same scale used for the EVA-K was used to score the EVA-4. Interrater reliability among the RAs was established through Cohen's kappa at 0.93. Coefficient H was 0.94 at pretest and 0.95 at posttest. The correlation between the RAV-4 and the GMRT-V was 0.76 at pretest and 0.73 at posttest.

5. Analysis

Observations were taken repeatedly on the same students and students were nested within classrooms meaning that data were clustered both within students and within classrooms. The clustering at the classroom level was meaningful (DEFT = 1.73–2.15, ICC = 0.11–0.23)[1] and thus non-ignorable. Although this data structure traditionally would call for a three-level HLM, aspects of the data and the research question make HLM less than ideal (McNeish & Wentzel, 2017). From a data perspective, with 12 classrooms, it is difficult to verify whether the random effects are reasonably normally distributed or whether the random effects are reasonably uncorrelated with any classroom-level predictors (McNeish & Stapleton, 2016).

More importantly, inferences to specific classrooms were not an explicit research interest in this study. The interest in this study was on assessing whether different media types more effectively increased vocabulary while accounting for the fact that the data were clustered. We therefore bypassed multilevel models in favor of a clustered-errors model, a design-based method that can similarly account for clustering as with HLM without requiring random effects (McNeish, Stapleton, & Silverman, 2017). Even though the data are clustered within students which are nested within classrooms, design-based methods only require that the highest meaningful level of clustering be taken into account (Cameron, Gelbach, & Miller, 2011; Pepper, 2002), which is the classroom level in this data. As an advantage of clustered-error models, the lack of random effects results in straightforward calculation of effect sizes, which can be challenging when using HLM for clustered data (Hayes & Cai, 2007; McNeish et al., 2017).

As alluded to previously, the small number of classrooms must be considered because clustered-error models (as well as HLM) are known to encounter issues with small numbers of clusters (e.g., Lu et al., 2007). With clustered-error models, a handful of small sample corrections exist and have been shown in simulation studies to perform well with as few as 10 clusters (Morel, Bokossa, & Neerchal, 2003). Because the primary research interest was on a within-cluster predictor (the difference between different media types), the simulation study by Lu et al. (2007) suggests that the Mancl-DeRouen correction (Mancl & DeRouen, 2001) performs best. Models were run in SAS 9.4 in Proc Glimmix, which allows for application of the Mancl-DeRouen correction. To err on the side of conservatism, we tested effects with a *t*-distribution with 10 degrees of freedom for all tests, which is based on the number of classrooms minus the treatment and media type predictors (Cameron & Miller, 2015).

5.1. Results

Descriptive statistics for kindergarten and fourth grade variables are provided in Tables 1 and 2, respectively. The primary interest of this study is whether treatment effects differ across media types, so all models will necessarily contain a Treatment × Media Type interaction term. However, the control variables (e.g., the standardized vocabulary measure) are not of direct interest and may be constrained to be equal across media types, if appropriate, to form a more parsimonious model. Likelihood ratio tests are used to compare the fit of models that do and do not constrain these effects. Results showed that the pre-test score should have a different estimated effect for each media type in both kindergarten models but that all other effects can be reasonably constrained to a common value across media types.

Clustered-error models allow users to specify a marginal covariance matrix to capture relations between individuals in the same cluster. This allows researchers to recreate the marginal covariance that would be obtained with HLM without having to use random errors or make the assumptions they require. With the clustering of students within classrooms present in this study, two competing covariance structures are typically plausible, the independent structure and the exchangeable structure (McNeish, 2014). For each model, these two structures were compared using the likelihood ratio test, AIC, and BIC. For all models except the RAV post-test score for kindergarten students, the exchangeable structure provides much better model fit. For the RAV post-test score for kindergarten students, the likelihood ratio test for the exchangeable structure providing better fit was on the borderline of statistical significance ($\chi^2(1)$, $p = .06$) and both the AIC (independent = 2254, exchangeable = 2253) and BIC (independent = 2256, exchangeable = 2254) were lower for the exchangeable structure. Based on these values, all four models used an exchangeable covariance structure. Note that an exchangeable marginal covariance produces identical within-cluster correlations as a random-intercepts HLM (Fitzmaurice, Laird, & Ware, 2004, pp. 193–194). Therefore, we did not ignore possible classroom effects that appear as random effects in HLM, but rather we marginalized them in the covariance structure. In this way, we accounted for covariance that would arise from possible classroom effects as one would in HLM, but the

[1] DEFT is calculated by DEFT = $\sqrt{1 + (1 - m)\text{ICC}}$ where m is the average cluster sizes. The DEFT estimates the ratio of standard errors that account for clustering to standard errors that ignore clustering. Values above about 1.40 are typically seen as necessitating clustered data methods (Lai & Kwok, 2015; Muthen & Satorra, 1995).

Table 1
Descriptive statistics for kindergarten students in the sample.

	Comparison		Intervention	
	Pre-Test Mean (SD)	Post-Test Mean (SD)	Pre-Test Mean (SD)	Post-Test Mean (SD)
Non-ESOL	n = 43		n = 51	
RAV Print	3.19 (1.65)	4.12 (1.66)	4.14 (1.73)	6.57 (1.89)
RAV Video	4.70 (1.85)	5.30 (2.01)	5.29 (1.69)	8.25 (2.38)
RAV Electronic	4.72 (2.12)	5.05 (1.45)	5.94 (1.73)	7.20 (2.25)
EVA Print	1.65 (1.82)	2.67 (2.00)	2.53 (2.28)	4.63 (3.14)
EVA Video	3.98 (1.75)	4.67 (1.71)	4.57 (1.59)	7.00 (1.89)
EVA Electronic	3.63 (1.76)	3.88 (1.12)	4.71 (1.36)	5.55 (1.92)
ESOL	n = 48		n = 61	
RAV Print	2.52 (1.34)	2.77 (1.39)	2.90 (1.63)	4.72 (2.25)
RAV Video	3.31 (1.63)	3.58 (1.41)	3.25 (1.62)	5.83 (2.31)
RAV Electronic	4.04 (1.75)	4.88 (1.42)	4.51 (1.53)	5.57 (2.04)
EVA Print	0.44 (1.17)	0.75 (1.12)	0.67 (0.94)	1.80 (1.88)
EVA Video	2.79 (1.44)	3.00 (1.32)	2.75 (1.42)	5.05 (1.99)
EVA Electronic	3.38 (1.33)	3.92 (1.22)	3.69 (1.44)	4.41 (1.64)
Total sample	n = 91		n = 112	
RAV Print	2.84 (1.52)	3.41 (1.66)	3.46 (1.78)	5.56 (2.28)
RAV Video	3.97 (1.86)	4.40 (1.91)	4.18 (1.94)	6.94 (2.63)
RAV Electronic	4.36 (1.95)	4.96 (1.43)	5.16 (1.77)	6.31 (2.28)
EVA Print	3.35 (1.70)	3.79 (1.72)	3.58 (1.75)	5.94 (2.17)
EVA Video	1.01 (1.62)	1.66 (1.86)	1.52 (1.92)	3.09 (2.89)
EVA Electronic	3.49 (1.54)	3.90 (1.16)	4.15 (1.49)	4.93 (1.85)

Table 2
Descriptive statistics for fourth grade students in the sample.

	Comparison		Intervention	
	Pre-Test Mean (SD)	Post-Test Mean (SD)	Pre-Test Mean (SD)	Post-Test Mean (SD)
Non-EL	n = 66		n = 84	
RAV Print	7.97 (1.65)	8.44 (1.64)	7.46 (2.19)	9.13 (1.68
RAV Video	7.03 (1.87)	7.73 (1.75)	6.43 (2.15)	8.92 (1.50)
RAV Electronic	7.39 (1.94)	7.48 (1.87)	6.67 (2.10)	8.71 (1.67)
EVA Print	6.45 (3.26)	7.48 (3.64)	5.45 (3.08)	8.56 (4.16)
EVA Video	5.79 (3.85)	6.24 (4.00)	4.35 (3.66)	8.51 (4.31)
EVA Electronic	6.10 (3.60)	8.09 (4.48)	5.01 (3.40)	9.67 (4.40)
EL	n = 42		n = 47	
RAV Print	6.48 (1.97)	6.79 (2.24)	5.49 (2.18)	8.21 (2.11)
RAV Video	5.54 (2.21)	6.14 (1.73)	5.26 (2.34)	7.68 (2.32)
RAV Electronic	6.05 (2.21)	6.26 (1.99)	4.77 (2.33)	7.55 (2.30)
EVA Print	3.12 (2.12)	3.95 (2.59)	3.11 (2.31)	5.32 (3.59)
EVA Video	1.83 (2.17)	2.31 (2.57)	2.38 (2.45)	5.11 (3.49)
EVA Electronic	2.76 (2.38)	4.12 (3.26)	2.68 (2.47)	6.85 (3.96)
Total sample	n = 108		n = 131	
RAV Print	7.39 (1.92)	7.80 (2.05)	6.76 (2.37)	8.80 (1.89)
RAV Video	6.45 (2.13)	7.11 (1.90)	6.01 (2.28)	8.47 (1.92)
RAV Electronic	6.87 (2.14)	7.01 (2.00)	5.98 (2.35)	8.30 (1.99)
EVA Print	5.16 (3.30)	6.11 (3.69)	4.61 (3.04)	7.40 (4.25)
EVA Video	4.25 (3.81)	4.71 (4.00)	3.64 (3.40)	7.29 (4.34)
EVA Electronic	4.80 (3.56)	6.54 (4.48)	4.18 (3.29)	8.66 (4.44)

marginal approach we took was able to do so while avoiding normality and exogeneity assumptions about higher-level random effects that would be required in HLM.

5.2. Kindergarten model estimates

The primary effect of interest was the Treatment × Media interaction which captured differences in the treatment effect by media type. A multiparameter Wald test for this effect was statistically significant both for the RAV post-test score model ($\chi^2(2) = 25.30$, $p < 0.1$) and for the EVA post-test score model ($\chi^2(2) = 25.04$, $p < 0.1$). This indicates that the treatment effect is different for at least one pair of media types. Regression coefficients, which represent kindergarten students scoring at the grand-mean on pre-test measures, for both models are presented in Table 3. Table 4 includes inferential tests for equality of treatment effect across media types for kindergarten students. Results are provided for ELs and non-ELs.

Table 3
Coefficient estimates for kindergarten student models. Cohen's d effect sizes are shown in parentheses.

Effect	Media Type	EL	RAV Estimate	EVA Estimate
Intercept				
	Electronic		5.17	3.83
	Print		3.61	1.60
	Video		4.59	3.85
Treatment				
	Electronic	Non-EL	1.34** (0.27)	1.03** (0.26)
	Print	Non-EL	2.10** (0.70)	1.29* (0.20)
	Video	Non-EL	2.28** (0.55)	1.76** (0.64)
	Electronic	EL	0.65* (0.18)	0.42 (0.15)
	Print	EL	1.64* (0.25)	0.85* (0.23)
	Video	EL	2.25** (0.64)	1.96** (0.66)
Pre-Test				
	Electronic		0.33**	0.24*
	Print		0.25**	0.15
	Video		0.25	0.20
GSV Pre-Test				
	Electronic		0.02**	0.01
	Print		0.05**	0.07*
	Video		0.07**	0.06*

Note that p-values (*p < .05, **p < .01) are based on a *t*-test with 10 degrees of freedom.

Table 4
Inferential tests for equality of treatment effect across media types in kindergarten.

Contrast	RAV		EVA	
	Difference (*p*)	Effect size (*d*)	Difference (*p*)	Effect size (*d*)
Non-EL				
Electronic-Print	−0.76 (.16)	0.13	−0.26 (.66)	0.04
Video-Electronic	**0.94 (.01)**	0.26*	**0.73 (.05)**	0.19
Video-Print	0.18 (.68)	0.04	0.47 (.30)	0.09
EL				
Electronic-Print	−1.00 (.13)	0.14	−0.43 (.15)	0.13
Video-Electronic	**1.60 (< .01)**	0.44*	**1.53 (< .01)**	0.54**
Video-Print	0.61 (.34)	0.08	**1.11 (< .01)**	0.33*

Note: Bold entries indicate statistically significant differences, *p*-values are based on a *t*-test with 10 degrees of freedom; * = small effect, ** = medium effect (Cohen, 1988); effect sizes in this table are Cohen's *d*.

RAV post-test score. For the RAV post-test score model, the treatment effect for the print text media type was statistically significant with a non-negligible effect sizes for both non-EL students ($B = 2.10$, $t\ (10) = 8.45$, $p < .01$, $d = 0.70$) and EL students ($B = 1.64$, $t\ (10) = 2.98$, $p < .01$, $d = 0.25$). The difference in the treatment effect for the video media type was not statistically significant from the treatment effect for the print text media type either for non-EL students ($B = 0.18$, $t\ (10) = -0.43$, $p = .68$, $d = 0.04$) or EL students ($B = 0.61$, $t\ (10) = 1.01$, $p = .34$, $d = 0.08$). The video media type treatment effect was statistically significant with a medium effect size for both non-EL students ($B = 2.28$, $t\ (10) = 6.61$, $p < .01$, $d = 0.55$) and EL students ($B = 2.25$, $t\ (10) = 7.75$, $p < .01$, $d = 0.64$). The difference in the treatment effect for the electronic text media type compared to the print media type was not statistically significant either for non-EL students ($B = -0.76$, $t\ (10) = -1.54$, $p = .16$, $d = 0.13$) or EL students ($B = -1.00$, $t\ (10) = -1.67$, $p = .13$, $d = 0.14$). The electronic text media type treatment effect was

significant for non-EL students ($B = 1.34$, t (10) = 3.27, $p < .01$, $d = 0.27$) and EL students ($B = 0.65$, t (10) = 5.16, $p = .05$, $d = 0.18$). The difference in the treatment effect for the video media type and the electronic text media type was statistically significant for both non-EL students ($B = 0.94$, t (10) = 3.10, $p = .01$, $d = 0.26$) and for EL students ($B = 1.60$, t (10) = 5.28, $p < .01$, $d = 0.44$).

EVA post-test score. For the EVA post-test score model, the treatment effect for the print text media type was statistically significant with a small effect size for both non-EL students ($B = 0.1.29$, t (10) = 2.48, $p = .03$, $d = 0.20$) and EL students ($B = 0.85$, t (10) = 2.79, $p = .02$, $d = 0.23$). The difference in the treatment effect for the video media type and the print media type was not statistically significant for non-EL students ($B = 0.47$, t (10) = 1.09, $p = .30$, $d = 0.09$) but the video media type treatment effect was significantly higher for EL students ($B = 1.11$, t (10) = 3.99, $p < .01$, $d = 0.33$) The video media type treatment effect was statistically significant with a medium effect size for both non-EL students ($B = 1.76$, t (10) = 7.79, $p < .01$, $d = 0.64$) and EL students ($B = 1.96$, t (10) = 7.94, $p < .01$, $d = 0.66$) The difference in the treatment effect for the electronic media type and the print media type was not statistically significant for either non-EL student ($B = -0.26$, t (10) = -0.45, $p = .66$, $d = 0.04$) or EL students ($B = -0.43$, t (10) = -1.55, $p = .15$, $d = 0.09$). The electronic media type treatment effect was significant with a small effect size for non-EL students ($B = 1.03$, t (10) = 3.11, $p = .01$, $d = 0.26$) but was not significant for EL students ($B = 0.42$, t (10) = 1.81, $p = .10$, $d = 0.15$). The treatment effects for the video media type was significantly higher than for the electronic media type for both non-EL students ($B = 0.73$, t (10) = 2.23, $p = .05$, $d = 0.19$) and EL students ($B = 1.53$, t (10) = 6.50, $p < .01$, $d = 0.54$).

5.3. Fourth grade model estimates

As with the kindergarten models, the primary effect of interest in the fourth grade models is the Treatment × Media interaction which captured differences in the treatment effect by media type. A multi-parameter Wald Type III test was calculated for this effect and was statistically significant both for the RAV post-test score model ($\chi^2(2) = 6.32$, p = .04) and for the EVA post-test score model ($\chi^2(2) = 27.92$, p < .01). This indicates that the treatment effect is different for at least one pair of media types. Table 5 includes the treatment effect estimates for fourth grade students scoring at the grand-mean on pre-test measures, and Cohen's d effect sizes are shown in parentheses. Table 6 includes inferential tests for equality of treatment effect across media types for fourth grade students. As with kindergarten, results are provided for ELs and non-ELs.

Table 5
Coefficient estimates for fourth grade student models.

Effect	Media Type	EL	RAV Estimate	EVA Estimate
Intercept				
	Electronic		7.41	6.30
	Print		8.31	5.97
	Video		7.52	4.58
Treatment				
	Electronic	Non-EL	1.80** (0.53)	2.93** (0.62)
	Print	Non-EL	1.37** (0.38)	1.95** (0.55)
	Video	Non-EL	1.79** (0.44)	3.24** (0.43)
	Electronic	EL	1.30 (0.15)	1.20* (0.18)
	Print	EL	1.22** (0.41)	0.29 (0.05)
	Video	EL	0.32 (0.32)	1.34 (0.13)
Pre-Test				
	Electronic		0.38**	0.69**
	Print		0.44**	0.69**
	Video		0.28**	0.57**
GATES-V Pre-Test			0.01**	0.03*

Note that p-values (*p < .05, **p < .01) are based on a t-test with 10 degrees of freedom.

Table 6
Inferential tests for equality of treatment effect across media types for fourth grade students.

Contrast	RAV		EVA	
	Difference (p)	Effect size (d)	Difference (p)	Effect size (d)
Non-EL				
Electronic-Print	0.42 (.16)	0.11	**0.97 (< .01)**	0.27*
Video-Electronic	−0.01 (.98)	0.00	0.31 (.60)	0.04
Video-Print	0.42 (.17)	0.11	**1.28 (.01)**	0.24*
EL				
Electronic-Print	0.08 (.91)	0.01	0.91 (.07)	0.15
Video-Electronic	−0.97 (.09)	0.14	0.15 (.88)	0.01
Video-Print	−0.90 (.28)	0.09	1.05 (.29)	0.08

Note: Bold entries indicate statistically significant differences, p-values are based on a t-test with 10 degrees of freedom; * = small effect, ** = medium effect (Cohen, 1988); effect sizes in this table are Cohen's d.

RAV post-test score. For the RAV post-test score model, the treatment effect for the print text media type was statistically significant for both non-EL students ($B = 1.37$, t (10) = 5.09, $p < .01$, $d = 0.38$) and for EL students ($B = 0.73$, t (10) = 1.22, $p < .01$, $d = 0.41$). The difference for the treatment effects between the video media type and the print media type was not statistically significant for either the non-EL students ($B = 0.42$, t (10) = 1.49, $p = .17$, $d = 0.11$) or the EL students ($B = -0.90$, t (10) = -1.14, $p = .28$, $d = 0.09$). The video media type treatment effect was statistically significant for non-EL students ($B = 1.79$, t (10) = 5.89, $p < .01$, $d = 0.44$) but was not significant for EL students ($B = 0.32$, t (10) = 0.39, $p = .70$, $d = 0.03$). The difference between the treatment effect for the electronic text media type and the print media type was not significant for non-EL students ($B = 0.42$, t (10) = 1.51, $p = .16$, $d = 0.11$) nor EL students ($B = 0.08$, t (10) = 0.12, $p = .91$, $d = 0.01$) The electronic text media type treatment effect was statistically significant with a medium effect size for non-EL students ($B = 1.80$, t (10) = 7.01, $p < .01$, $d = 0.53$) but was not statistically significant for EL students ($B = 1.30$, t (10) = 2.02, $p = .07$, $d = 0.15$). The difference for the treatment effect of the video media type and the electronic media type was not significant for neither non-EL students ($B = -0.01$, t (10) = -0.02, $p = .98$, $d = 0.00$) nor EL students ($B = -0.97$, t (10) = -1.88, $p = .09$, $d = 0.14$).

EVA post-test score. For the EVA post-test score model, the treatment effect for the print media type was statistically significant for non-EL students ($B = 1.95$, t (10) = 7.29, $p < .01$, $d = 0.55$) but was not significant for EL students ($B = 0.29$, t (10) = 0.70, $p = .50$, $d = 0.05$). The difference between the treatment effect for the video media type and the print media type treatment effect was statistically significant for non-EL student ($B = 1.28$, t (10) = 3.16, $p < .01$, $d = 0.24$) but was not significant for EL students ($B = 1.05$, t (10) = 1.12, $p = .29$, $d = 0.08$). The video media type treatment effect was statistically significant ($B = 3.24$, t (10) = 5.66, $p < .01$, $d = 0.43$) but was not significant for EL students ($B = 1.34$, t (10) = 1.71, $p = .12$, $d = 0.13$). The difference in the treatment effect for the electronic media type and the print media type was significant for non-EL student ($B = 0.97$, t (10) = 3.54, $p < .01$, $d = 0.27$) but was not significant for EL students ($B = 0.91$, t (10) = 2.02, $p = .07$, $d = 0.15$). The electronic media type treatment effect was significant for both non-EL students ($B = 2.93$, t (10) = 8.20, $p < .01$, $d = 0.62$) and was significant for EL students ($B = 1.19$, t (10) = 2.41, $p = .04$, $d = 0.18$). The difference between the video media type treatment effect and the electronic media type was not significant for either non-EL students ($B = 0.31$, t (10) = 0.54, $p = .60$, $d = 0.04$) nor EL students ($B = 0.15$, t (10) = 0.16, $p < .88$,

$d = 0.01$).

6. Discussion

The overarching goal of the present study was to compare print text, video, and electronic text as contexts for word learning, holding methods of instruction, which included teacher-led lessons and cross-age peer learning, constant across media types. In addition, analyses were meant to examine differential effects by grade level (kindergarten or fourth grade), language status (EL or non-EL), and types of vocabulary knowledge (receptive or expressive). In general, findings suggest that there were differential effects of media type on word learning and, to some extent, effects differed across grades, language backgrounds, and knowledge types, suggesting that the answer to which media types provide the best context for word learning may be complicated and depend on a variety of factors. Findings from the present study provide some initial indications of how effects of media types vary according to these factors. Eventually, as research accumulates in this direction, researchers may be able to provide guidance to curriculum developers and practitioners about how to use different types of media to optimally support vocabulary learning in linguistically diverse elementary schools.

In kindergarten there were significant, positive effects of all media types on receptive vocabulary learning for ELs and non-ELs. There were significant, positive effects of the print and video media types for ELs and non-ELs on expressive vocabulary, but the electronic text type showed positive, significant effects for non-ELs only. It could be that the electronic text type, with its hypertext and interactive features, overtaxed the cognitive load of the kindergarten ELs in particular because they are still in the beginning stages of learning English and coordinating their native language and English language knowledge in school. Though the added information may not have prevented them from gaining receptive knowledge of a word, it may have prevented them from gaining the more in-depth knowledge needed in expressive vocabulary tasks.

In comparing the effects of the different media types in kindergarten, there were no differences in effects for the video and print media types for receptive vocabulary of ELs and non-ELs, but there was a difference for expressive vocabulary for ELs though this was not seen with non-ELs. Thus, in this study, video was more supportive than print for the expressive vocabulary learning of ELs. In addition, there were positive and significant effects of video over electronic texts for non-ELs and ELs on receptive and expressive tasks, suggesting that videos may be more supportive of kindergarten word learning than electronic texts. Though not significant, there were also trends in the data of print over electronic text for non-ELs and ELs, particularly for receptive vocabulary. Together, these findings suggest that, for ELs, video is a more productive context then print text; for ELs and non-ELs, video is a more supportive context for vocabulary learning than electronic texts; and electronic texts may not be particularly productive for vocabulary learning as compared to video and print texts for kindergarten students.

The finding that video is more helpful than text for the word learning of ELs echoes research by Silverman and Hines (2009) in which lower elementary ELs learned more words in a condition including video than their peers in a condition that did not include video, though the effect of video over print in that study was on a receptive measure and the effect of video over print in this study was on an expressive measure. The finding in this study for an effect of video over print on expressive but not receptive vocabulary aligns with the theory by Verhallen and Bus (2011) that suggests that the added information about words provided in multimedia may not make a difference for relatively more easily acquired receptive word knowledge but does make a difference for relatively more difficult to acquire expressive knowledge of words. Of note, the finding for video over print runs counter to the findings reported in Silverman (2013), in which there was no difference in kindergarten word learning through video versus print on receptive or expressive measures. Additionally, the finding that video is more supportive than electronic texts in this study seems to counter findings by Smeets and Bus (2015) that suggest that kindergarten children learn more vocabulary via interactive animated e-books than (noninteractive) animated e-books, which could be considered analogous to electronic texts versus video in this study. However, in the Smeets and Bus (2015) study, the interactive animated e-books had some features of video (e.g., moving pictures), which were not included in the electronic texts in the present study, and the use of hotspots and interactives was more controlled. For example, in Smeets and Bus (2015), in the interactive animated e-books, the animated story stopped; children were given 30 s to search for the hotspot; if they did not find it within 30 s the hotspot activated automatically; then the animated story continued. In the present study, students had freedom to engage with the hotspots as much or as little as they wanted during the reading buddies session. It could be that these differences in electronic texts result in different findings. This should be explored in future research.

In fourth grade, there were positive and significant treatment effects of all three types of media on receptive and expressive vocabulary for non-ELs; however, for ELs, there were positive and significant effects only on the print text for receptive vocabulary and for electronic text for expressive vocabulary. In comparing media types, for non-ELs, there was a positive and significant effect of electronic versus print text as well as of video versus print text on expressive, but not receptive, vocabulary knowledge. For ELs, comparisons of text types showed no significant differences on receptive or expressive measures.

The strength of the effect of electronic text versus print text in fourth grade for non-ELs and the treatment effect of electronic text for ELs on the expressive vocabulary measure diverges from the kindergarten findings suggesting that while electronic text may overwhelm younger students, including non-ELs, by fourth grade students may have developed the skills to be able to coordinate and even take advantage of the additional information provided through the interactive nature of electronic texts. It is curious that the only treatment effects on receptive vocabulary for ELs was in the print medium and that there were no effects for print and video on expressive vocabulary knowledge and no significant differences between the different types of media for receptive of expressive knowledge for these students. It may be that using the different media types while navigating a second language and also guiding a kindergarten student through the buddy reading activity may result in more haphazard word learning for these students.

Findings from this study add to research on the use of different types of media in upper elementary school. While in this study, electronic texts seemed to be the least helpful media type for EL and non-EL kindergarten children's word learning, electronic texts seemed to be more supportive than print texts for non-EL 4th grade word learning as measured via an expressive task. However, the relative lack of effects of electronic text for ELs runs counter to findings by Proctor et al. (2007) and Proctor et al. (2011) that multimedia enhanced texts can support word learning of upper elementary school students, including ELs. Additionally, findings suggest that video may be more supportive than print text for upper elementary school expressive word learning, at least for non-ELs. This finding is in line with research by Xin and Rieth (2001) which suggests that video may be more helpful than print for word learning in 4th–6th grades as well as research by Lowman and Dressler (2016) indicating positive effects of print plus video over print only on upper elementary students' word learning. The relatively limited effects across media for ELs, if associated with the complex context in which multimedia was used as hypothesized above, may suggest that not only the grade level, language status, and vocabulary task but also the context for how different media is used should be considered in future research. Furthermore, as mentioned in the introduction, elementary EL students' executive functioning skills may be particularly relevant as they coordinate different language demands in different contexts. The role of executive functioning in influencing elementary EL

students' ability to acquire vocabulary through different media types should be explored in the future.

Given the limited scope of this study, it is unsurprising that the magnitudes of the treatment effects are relatively small. However, it is important to note that the intervention was short (2 times/week over 14 weeks) and the engagement with the various media (2 times/week for 4 weeks each) was relatively limited. Future research must investigate the effects for different media at different grade levels over a longer term. However, the present study offers some initial insights that can guide future research.

It is interesting that results varied by grade level and type of measure. Video may be particularly helpful for younger children because they benefit most from the highly visual nature of video. Video and electronic texts may be more helpful for older children because they have more experience using technology to learn and they can take greater advantage of the interactive nature of electronic texts than their younger peers. These hypotheses should be explored through further quantitative, qualitative, and mixed methods research as in the research by Martin-Beltran, Tigert, Peercy, & Silverman (2017). Differences in how younger and older learners and non-ELs and ELs engage with different types of media may explain differential treatment effects on different types of measures. Though effects were consistent across both receptive and expressive measures for some contrasts, additional contrasts between media types appeared on the expressive vocabulary rather than the receptive vocabulary measure. It could be that the different types of media effect these two kinds of word knowledge differentially, or it could be that the expressive measure, which captures different levels of word knowledge, is just more sensitive to treatment effects than the receptive measure. Given that many studies do not include both types of measures, it is important to further disentangle differences between media across receptive and expressive assessment types in future research.

There are several limitations with the present study. First and foremost, in this study, content across media types was not handled exactly the same. In order to capture the affordances provided by different types of media, content was delivered with typical features of each media type. Therefore, the print texts included text boxes with definitions and a glossary; videos included definitions and action shots; and electronic texts included hyperlinks and interactives including end-of-text quizzes. These differences may confound the effect of media type on vocabulary learning; however, since these differences are inherent to the media types it is worth capturing how the different media, as they typically manifest, affect words learning. Future studies should try to tease out how specific differences in media types lead to differences in word learning and this could be done by having some features exactly the same and manipulating other features individually in separate studies. Additionally, while exploring the effects of different media in the context of a larger program allowed us to keep instruction constant across the media types, it also limits the generalizability of the findings to other contexts. Further research should investigate how different classroom contexts (e.g., teacher-led instruction, partner activities, independent learning) interact with different media types for different grade levels, language backgrounds, and vocabulary measures.

As the role of technology in education grows over time, it is important to understand how different media compare for different skills and for children from different grade levels. This study adds to the research base on the role of different media on vocabulary learning for kindergarten and fourth grade EL and non-EL students and suggests that it may be important to consider differences by grade level, language background, and by assessment task (i.e., receptive or expressive tasks). Research along these lines may be able to guide curriculum developers and teachers in choosing media to support word learning in the classroom.

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