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Supporting Vocabulary Teaching and Learning in Prekindergarten: The Role of Educative Curriculum Materials

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The purpose of this study was to support teachers' child-directed language and student outcomes by enhancing the educative features of an intervention targeted to vocabulary, conceptual development and comprehension. Using a set of design heuristics (Davis & Krajcik, 2005), our goal was to support teachers' professional development within the curriculum materials. Ten pre-K classrooms with a total of 143 children were randomly selected into treatment and control groups. Observations of teacher talk, including characteristics of lexically-rich and cognitively demanding language were conducted before and during the intervention. Measures of child outcomes, pre- and post-intervention included both standardized and curriculum-based assessments. Results indicated significant improvements in the quality of teachers' talk in the treatment compared to the control group, and significant gains for child outcomes. These results suggest that educative curriculum may be a promising approach to facilitate both teacher and student learning.

Vocabulary knowledge and oral language comprehension is central to children's early and long-term literacy success (Cunningham & Stanovich, 1997). Studies have shown that the size of a child's vocabulary in kindergarten is an effective predictor of reading comprehension in the middle elementary years (Scarborough, 2001), and vocabulary size at the end of Grade 1 is a significant predictor of reading fluency and comprehension in high school (Stahl & Nagy, 2006).

Consequently, the well-documented gap in vocabulary knowledge between economically disadvantaged children and their middle-class peers prior to entering the elementary school years (Hart & Risley, 1995) is of critical concern if experts are to improve reading achievement and decrease the knowledge disparities among poor and middle-income children (Farkas &

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Beron, 2004). Moats (1999), for example, estimated that the difference in vocabulary knowledge at entry into first grade may be as large as 15,000 words, with linguistically disadvantaged children knowing as few as 5,000 words and their more advantaged peers perhaps as many as 20,000 words. Hart and Risley (2003) argued that the accumulated experiences with words for children who come from high-poverty circumstances compared with children from professional families may constitute a 30-million word catastrophe that is difficult, if not impossible, to close over time.

As compelling as these figures are, they may actually underestimate the problems associated with vocabulary differentials and school learning, failing to capture differences in deeper conceptual knowledge and organization. As children get older, they will increasingly need academic vocabularies that consist of words and precise meanings that are central to content area understanding and often differ from general meanings of even the same terms (e.g., *operation* has a very specific meaning in mathematics; Beck, McKeown, & Kucan, 2002). These academic terms and their specialized meanings may pose the greatest challenges in the age of Common Core standards for children who lack a rich storehouse of conceptual knowledge and those who face the additional challenges of learning a new language (Mol & Neuman, 2014).

Despite its importance, recent observational studies report a paucity of intentional vocabulary instruction in primary classrooms (Wright & Neuman, 2014). For example, in a study of 55 kindergarten classrooms involving more than 600 hr of observation, researchers found no instances of planned vocabulary instruction. Instead, teachers appeared to rely on teachable moments, or teacher-friendly definitions of words interspersed within lessons. Even more troubling was the observation that the frequency and challenge level of these teachable moments varied dramatically by kindergartners' socioeconomic status: Children from poor areas were typically introduced to two fewer words per day, many of which were of limited challenge (e.g., Tier 1 words), compared to their higher income peers, who received almost double the number of words and greater challenge (e.g., Tier 2 words).

Furthermore, a recent study of 44 third-grade teachers teaching in high-poverty areas reported a pattern of vocabulary instruction not all that dissimilar (Carlisle, Kelcey, & Berebitsky, 2013). Examining the nature of discourse actions teachers used to support vocabulary learning in different literacy lessons, Carlisle and her colleagues (2013) found that teachers rarely engaged students in cognitively challenging work on word meanings despite its reported usefulness in promoting reading comprehension. Teachers tended to focus students' attention on unfamiliar words but did not engage them actively in understanding word meanings and uses. Examining their data at the teacher level to discern differences in the variation of supports, Carlisle and her team reported an important insight: Teachers who were more knowledgeable about reading consistently provided greater support for students' vocabulary learning—33% more cognitively challenging actions—than less knowledgeable teachers. This suggests the possibility that efforts to improve teachers' knowledge of reading could lead to greater gains in children's vocabulary and comprehension.

Knowledge about reading, however, may not be sufficient to enhance practice (Moats, 1999). Recent studies (Neuman & Dwyer, 2009; Powell, Diamond, Burchinal, & Koehler, 2010) suggest that it is the ability to apply this knowledge in practice and to engage in a range of teacher practices, such as planning, lesson modification, and assessment that can promote student learning. For vocabulary development in particular, this may involve instructional actions that vary in the levels of engagement and depth of processing asked of students. In Carlisle et al.'s (2013) study, these instructional actions included such strategies as defining a word or fostering the discussion of a word. In early childhood classrooms, they may reflect the nature and quality of teachers' child-directed language in designing opportunities for children to use language for learning. For example, studies suggest that the variety and sophistication of adult language support is a significant predictor of children's developing vocabulary knowledge (Hart & Risley, 1995; Hoff, 2003; Mol & Neuman, 2014).

To date, however, curricular supports for early literacy and vocabulary in particular have shown little impact on teacher practice or child outcomes. Results from the most rigorous and comprehensive evaluation of preschool curricula, the Preschool Curriculum Evaluation Research Consortium (2008) project, an Institute of Education Sciences initiative that launched 14 randomized trials around the country, indicated limited effects. Overall, 10 of these curricula showed no statistically significant differences from business-as-usual instruction in the control classrooms on any of the student-level outcomes, and only two showed significant differences on even one outcome measured in kindergarten.

It has been hypothesized that in contrast to traditional teacher editions in core programs, curriculum materials could potentially support professional practice if they were created with closer attention to the processes of curriculum enactment (Ball & Cohen, 1996). Educators have begun to explore *educative curriculum materials* designed to promote student *and* teacher learning (e.g., pedagogical knowledge and content knowledge; Davis & Krajcik, 2005). In contrast to typical teachers' guides or scripts, educative curriculum materials are intended to increase teachers' knowledge in specific instances of instructional decision making while at the same time helping to develop more general knowledge about the domain that can be applied flexibly in new situations. In an ideal scenario, teachers incorporate these educative elements in the ways in which they enact the curriculum, emphasizing not only instructional features but their design and theoretical intentions as well.

Therefore, in this study, we attempted to embed educative features in a supplemental vocabulary intervention that was designed to promote word knowledge, conceptual development, and comprehension for low-income preschoolers. Previous trials of the intervention had shown evidence of positive effects (Neuman & Dwyer, 2011; Neuman, Newman, & Dwyer, 2011). However, like many intervention studies, we had relied on intensive coaching to support the enactment of the curriculum. In this coaching, we had modeled, demonstrated, and provided feedback on a weekly basis to enhance the quality and fidelity of the intervention—providing professional development that is often difficult to sustain over time in many school districts. Consequently, in designing our curriculum materials to become more educative, we attempted to take many of the lessons learned from our previous discussions with teachers to incorporate supports that could stand on their own. Our goal was examine whether such an educative curriculum could help teachers who had not used the materials before to enact the instructional lessons with fidelity to implementation: to understand that vocabulary contributes not only to knowledge of specific words but also to a growing knowledge network of concepts and content that is central to comprehension.

For this reason, teachers would need to support children to think about words in ways that went beyond their immediate context, draw relationships with words that required some abstraction and extension from the observable to the unobservable, and support reasonable inferences from text. Furthermore, teachers would provide more intentional linkages between vocabulary words and developing the content knowledge essential for comprehension. Such activity would require teachers to systematically support a continuum of conceptualization, ranging from relatively low cognitive demand to the higher cognitive demands inherent in representational language (Price, Bradley, & Smith, 2012).

Using a set of design heuristics developed by Davis and Krajcik (2005), we explicitly set out to design materials to support teachers' learning (described below). According to Ball and Cohen (1996), an educative curriculum offers support around (a) the content beyond the levels suggested for students (e.g., word learning, concepts related to life science) and (b) pedagogical knowledge (e.g., strategies for teaching, the reasoning behind a particular sequence and flow of lessons). By including these features within our curriculum, we attempted to guide teachers in experiences that would enable them to construct knowledge about vocabulary teaching and the connections between vocabulary, concepts, and content knowledge. Because curriculum materials are nearly ubiquitous in classrooms, if effective, such educative curriculum could have an important place in enhancing quality instruction in prekindergarten, where resources devoted to professional development have been minimal to nonexistent (Sheridan, Edwards, Marvin, & Knoche, 2009).

Consequently, in this article, we first describe the design of our educative materials and how we embedded these features in our existing vocabulary curriculum. Using a set of design heuristics developed by Davis and Krajcik (2005), we had as our goal to support teachers' professional development within the curriculum materials. We then describe a quasi-experimental study to examine the extent to which these materials improved teachers' linguistic interactions with children as well as children's outcomes on vocabulary, concepts, and comprehension skills. Our research was guided by two questions:

- Can an educative curriculum serve as a professional development tool to enhance teachers' child-directed language? In what ways might it influence the cognitive demand of teachers' talk?
- To what extent might an educative curriculum, without additional supports such as coaching, improve children's vocabulary, conceptual development, and comprehension?

THE INSTRUCTIONAL INTERVENTION

The World of Words (WOW; Neuman, Dwyer, Koh, & Wright, 2007) is an embedded multimedia supplemental intervention designed to support vocabulary and conceptual development for low-income prekindergarten children. The use of media is based on dual coding theory (Paivio, 2008), which posits that visual and verbal information are processed differently, and separate representations are created for information processed in each channel. Vocabulary words are introduced first through video clips and then through information books and picture cards, allowing children to develop an understanding of words in multiple contexts. The curriculum is organized by topics representing taxonomic categories (e.g., plants), with category-specific properties identified for each topic (e.g., plants need water, sunlight, and air to grow and survive).

Within our curriculum, vocabulary words are selected to represent key terms relevant to each taxonomic category. These words include primary words (e.g., *sunflower, shrub*), support words (e.g., *seed, topsoil*), and challenge words (e.g., *bouquet, pinecone*). Physical and conceptual properties are identified for each topic and introduced using the related vocabulary. Some properties are topic specific (e.g., plants have roots to help them live and grow), whereas other properties are shared across topics (e.g., all living things need food and water to survive). For example, during the topic on plants, children engage in using the vocabulary and conceptual properties related to plants (e.g., *sunflowers* grow from *seeds*) and discuss big ideas relating the characteristics and needs of plants to those of all living organisms (e.g., sunflowers have *life cycles* just like bees have *life cycles*).

The 8-day instructional sequence is designed to help teachers scaffold children's learning, moving on the continuum from low cognitive demand to cognitively challenging concepts and big ideas. In the beginning, for example, the teacher's lesson plan focuses on explicit instruction, helping children to get set (i.e., providing background information) and give meaning (i.e., providing concept-related information) to deepen their understanding of the topic. Many of the strategies engage children in questions that will demonstrate their understanding of what they have heard and seen. As the instructional sequence progresses, the teacher begins to build bridges to what children have already learned and what they will learn (i.e., establishing intertextual linkages across media). Here the teacher begins to release more control to the children, focusing on more cognitively demanding questions that require representational thinking. Finally, the teacher is encouraged to step back, giving children more opportunities for open-ended discussions that are designed to support inference generation and hypothesis building.

Results from our previous trials indicated that the curriculum could be highly effective in improving word knowledge, concept development, and content learning *with* supports. In a design study with expert teachers (i.e., as identified by their supervisors) and coaching, children in the treatment group improved not only their vocabulary but their conceptual knowledge, better justifying their generalizations about a domain, compared to children in a control group (Neuman & Dwyer, 2011). Subsequent studies, including a cluster randomized large-scale trial with Head Start teachers, further indicated that teachers could be effectively supported and significantly improve children's vocabulary and comprehension (Neuman, Newman, & Dwyer, 2011). However, in each case, we relied on intensive coaching to support teachers. In designing the curriculum material to become more educative, therefore, we followed guidelines from Davis and Krajcik (2005) and attempted to incorporate the effective supports used in the field to develop materials that could stand on their own.

THE EDUCATIVE FEATURES IN THE CURRICULUM

We included five new features in our redesign of the curriculum, indicated by color-coded panels throughout each topic's instructional guide.

First, based on our previous trials, we recognized that our educative materials could be helpful in creating an anticipatory set for teachers. In other words, we could help teachers learn how to anticipate and interpret what their young learners might think about or do in response to the instructional activities. To do this, we created *at-a-glance* sections to enable teachers to focus on the key ideas or concepts that could help children begin to build knowledge networks and big ideas. For example, *at a glance* might highlight common properties of a topic, such as "A dolphin is a marine mammal. Marine mammals have lungs and live in the ocean." These statements were designed to build more intentional connections between the words children were learning and the concepts they represent.

Second, previous research by Schneider and Krajcik (2002) reported that placing information about science *for teachers* within the curriculum could help to support the materials teachers were using. In a similar vein, we created brief information notes throughout the lesson, giving teachers facts and concepts about the specific topic. Within the topic, the teacher would find facts such as “Marine Mammal Note: Some marine mammals, such as the dolphin, do not look like they have hair/fur, but hair follicles are present in the young. The children can explore this further in the classroom.” In addition, we developed a glossary for each topic in the back of the manual to provide clear and simple definitions (with pronunciation guides) for key science words that might come up during class discussions.

Third, to help teachers develop the scientific big ideas that cut across the topics, we created connections between topics by suggesting how words and concepts related to one topic might be applied to another. For example, one of these information notes called out

> This part of the lesson links the category related words that children have heard and used to describe the life cycle of marine mammals to the life cycle of other wild animals in the previous topic. It provides repeated practice and review of these words and concepts in a new context.

In this respect, these educative elements were designed to help teachers develop their knowledge base about the subject matter and children’s developing content knowledge.

Fourth, we wanted to make the pedagogical design elements and their rationale more visible within the curriculum. Consistent with a gradual release of control (Tharp & Gallimore, 1988), the guide initially supported more explicit instruction. As the lessons continued, the teacher was encouraged to provide more open-ended response opportunities. To emphasize this feature, we included notes titled *Why do it this way?* For example

> Why this pattern of response? In this part of the lesson, you are helping children deepen their familiarity with the category and its properties. Call and response techniques can reinforce their understanding of those properties. It’s important that these understandings be well established before asking children to talk about the category by using more open-ended responses.

In another example, the *Why do it this way?* note read

> As in earlier lessons, this part of the lesson allows children to use category related words to review what they have learned about marine mammals. Here, however, you turn over to the children more responsibility for supplying the key words and information.

By making our intentions more visible and our rationale for these decisions more evident, we hoped to make connections between theory and practice and to provide the basis for the questions teachers might ask rather than merely guide their actions.

Fifth, we included educative features to help guide teachers’ observations of children’s behavior throughout the lesson in order to make necessary adaptations when needed to promote the instructional goals. Rather than merely implementing the curriculum, we wanted to support teachers in actively engaging in decision making—whether through repeated practice, change of pacing, or review and reteaching. Throughout the curriculum, we included simple reminders such as "To determine who might need extra help with the category, notice who is and is not responding to your questions." We also included more specific guidelines on the pedagogical design at different points throughout the curriculum. For example, in a section called *Extending responses,* one tip included, "Although you are asking more open-ended questions, this part of the lesson is nonetheless very guided because the children's responses need to be closely anchored to the information in the book." Subsequent guidance for pacing suggested the following:

> Keep the activity moving to support children's engagement. However, if you notice that some children are not catching on to different science concepts or vocabulary, interact separately with them during center times using key vocabulary. Or reread one of the dolphin books with them and have a discussion about the science concepts.

Therefore, our educative design features were grounded in some of the real challenges that both our expert and less experienced teachers faced in the previous enactments of the curriculum. We organized our support in recognition of the fact that many teachers in early childhood could benefit from subject matter knowledge about science, language/vocabulary development in early literacy, and pedagogical content knowledge for topics and disciplinary practices targeted to these domains. Our goal was to determine whether our curriculum with its educative features, and without additional supports, might enhance teachers' child-directed language and have positive implications for child outcomes in word knowledge, conceptual development, and comprehension of text.

METHOD

Research Sites and Participants

Ten state-sponsored prekindergarten classrooms targeted to at-risk children were recruited to participate in the study. Known as the Great Start Readiness Program, the state program was specifically designed to improve young children's skills in early language and literacy and mathematics. Classrooms were located in five elementary schools in a severely economically depressed urban fringe area in the rustbelt region of the United States. In each school, classrooms were randomly selected into treatment and control groups.

As required by the state program, all teachers had their bachelor's degree and a specialist certificate in early childhood. All teachers had more than 5 years of preschool teaching experience. Teachers were female and Caucasian. Class size ranged from 16 to 18 children in each session. Classrooms reported using High/Scope (Hohmann & Weikart, 1995) as their curriculum framework.

A letter was sent to parents informing them of the study, and all parent agreed to have their child participate in the assessments and intervention. A total of 73 children were in the treatment group, and 70 were in the control group. Demographic statistics indicated that the groups were comparable in age and receptive language, as measured by the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 2007). However, there were significant differences in gender (i.e., more boys in the treatment group) and ethnicity (i.e., more African American children in the treatment than the control group). All children spoke English as their primary language. See Table 1 for additional demographic information.

TABLE 1
Demographic Characteristics of Treatment and Control Groups ($N = 143$)

Characteristic	*Treatment* ($n = 73$)	*Control* ($n = 70$)
Age (in months)	52.27 (3.62)	51.53 (3.49)
Gender*		
Male	57.5%	44.3%
Female	42.5%	55.7%
Minority**	63.0%	28.6%
Ethnicity**		
Euro-American	37.0%	71.4%
African American	46.6%	14.3%
Hispanic	5.5%	8.6%
Asian		2.9%
Multiracial	7.1%	2.9%
English as primary language	98.7%	100%
Free or reduced lunch (school district)	62.4%	69.7%
PPVT pretest (standard score)	98.67 (13.28)	97.53 (15.32)

Note. PPVT = Peabody Picture Vocabulary Test–IV (Dunn & Dunn, 2007).
$^{*}p < .05$. $^{**}p < .01$.

Measurement of Teacher Talk

A primary goal of the research was to measure the quality of teacher language and determine the extent to which our educative curriculum might influence the cognitive demand of teachers' talk. To do this, we developed a measure designed to capture (a) the linguistic properties of teachers' child-directed talk and (b) the extent to which this talk was cognitively challenging. We adapted an observational protocol from our previous work assessing adult–child extratextual talk during information book reading (Wright & Neuman, 2014) to assess the full continuum of talk from low cognitive demand to high cognitive demand talk (Mol & Neuman, 2014). Based on the research literature, 10 components of teachers' language were measured, each of which has been reported to positively influence children's language development. See Table 2 for detailed definitions and examples of each component.

Three of these components focused on the *linguistic* properties of teachers' child-directed talk: (a) quantity of language, (b) variety and sophistication of vocabulary, and (c) repetition and paraphrasing. These components were designed to measure factors that have been shown to positively predict children's vocabulary acquisition across a variety of contexts (Hoff, 2003; Weizman & Snow, 2001).

Seven of these components focused on the extent to which teachers' child-directed language was *cognitively demanding and challenging,* calling for more representational language responses from children. *These cognitively challenging variables* addressed (a) conceptual questioning, (b) bridging, (c) categorization, (d) definitions, (e) generic noun phrases, (f) causal reasoning, and (g) metacognition. *Conceptual questioning* focused on instances in which the teacher intentionally created a specific problem, such as highlighting a gap in knowledge or creating a contradiction in expectations already in place, and asked children to retrieve the information necessary to resolve the problem (Chouinard, 2007). *Bridging* referred to talk that encouraged children to use past experiences as the basis for comprehending and making new

TABLE 2
Definitions and Examples of Constructs Observed in Teachers' Child-Directed Language

Construct	*Definition*	*Example*
Quantity of language	Teacher provides frequent language input in his or her interactions with students; input is often syntactically complex.	"Chameleons are lizards, I believe, that change colors to match their environments, which is called *camouflage*."
Variety and sophistication	Teacher exposes children to rich language input; sophisticated vocabulary is used consistently in teacher–child conversations.	"The tiger is *ferocious*! He's going to eat the warthog because he's a *carnivore*."
Repetition and paraphrasing	Teacher uses repetition and paraphrasing as a means of repeating instructions and main ideas. *Paraphrasing* means restating ideas in alternative ways to clarify meaning.	"The antennae help the ant communicate with his friend. It helps them to talk to each other."
Conceptual questioning	Teacher intentionally creates specific problems for children by highlighting incomplete knowledge, creating a contradiction in existing knowledge, or identifying ambiguous information. Questions are open ended and require children to provide information necessary to solve the problem.	"A century is a hundred years. How many legs do you think there might be if it's a centipede?"
Bridging	Teacher refers to past shared experiences in his or her discussions with students; higher level reminiscing makes explicit links between past and current experiences.	"Lobsters live underwater. Remember seeing them in the tank at Meijer? We could see the air bubbles from them breathing."
Categorization	Teacher intentionally groups entities/objects into categories and organizes those categories according to taxonomic relations, such as class inclusion.	"A salmon is a type of this animal. It's a fish."
Definitions	Teacher consistently labels entities/objects and makes an intentional effort to provide descriptions and definitions.	"Do you know what a *tigress* is? It means lady tiger, usually the mama tiger."
Generic noun phrases	Teacher uses generic noun phrases. A *generic noun phrase* is a noun phrase that refers to a kind or class of individuals, objects, or things (e.g., lions eat up to 30 kg in one sitting) rather than to a specific (set of) individual(s) (e.g., a lion is eating 30 kg of food).	"Tortoises live in the ocean. They get really big and live for over a hundred years."
Causal reasoning	Teacher discusses causal relations between objects and/or events; the causal relationships are often conceptual and nonobvious (i.e., not perceptually salient).	"Food and nutrients make you grow."
Metacognition	Teacher considers and evaluates one's thoughts, beliefs, and desires with incoming evidence.	"I thought they were zebras, but they're really tigers."

inferences about the present context (Tizard & Hughes, 1984). *Categorization* involved intentionally grouping entities and objects into semantic categories and organizing those categories according to meaningful relations, such as class inclusion (Gelman & Kalish, 2006; Gelman & Markman, 1986). *Definitions* were operationalized as intentional descriptions and/or demonstrations of word meanings that may have helped scaffold children's vocabulary acquisition, particularly when words described abstract concepts (Penno, Wilkinson, & Moore, 2002). *Generic noun phrases* referred to phrases that indicated a set (or a class) of things (e.g., "Insects have six legs") rather than an individual object or thing (e.g., "That insect has six legs”). Expressing rule-like knowledge about kinds or events is important for developing generalizations, which are the building blocks for concepts in knowledge networks (Gelman, Goetz, Sarnecka, & Flukes, 2008; Prasada, 2000). *Causal reasoning* reflected the intentional linkages and causal relations between objects and/or events (Booth, 2009; Kemler Nelson, O’Neil, & Asher, 2008), such as “Plants need light and water to grow.” Lastly, *metacognition* described conditional statements that considered the relationship between one’s conceptions and any evidence that might or might not support those conceptions. For example, “This picture made me think of a fox, but it’s really a coyote.” Studies (Palincsar & Brown, 1984; Mol & Neuman, 2014) suggest that evaluating the consistency and generalizability of one’s conceptions supports comprehension.

Each of these components was examined through observation using 4-point Likert scales (ranging from 1 = *not at all characteristic* to 4 = *very characteristic*). For example, in observing the use of categorization, a research assistant would record (1) “not at all characteristic” if there was no evidence at all of such statements; (2) “weakly characteristic” if only one or two instances; (3) “moderately characteristic” if the teacher identified words and their category membership more frequently, such as “Here’s a beetle, another living thing,” but did not use inclusion-like statements (e.g., “A beetle is a type of insect”); and (4) “very characteristic” in instances when both categories and inclusion statements were frequently observed. Prior to the start of the study, the second author conducted a pilot study with three research assistants to examine the feasibility of using the measure as an observational tool. After minor revisions to the detailed descriptions in the coding manual, three graduate research assistants new to the project were subsequently trained. Using videotaped teacher–child interactions that were not part of the present study, we carefully reviewed each scale and examined examples of what constituted “not at all characteristic” and “very characteristic.” Following training, research assistants viewed a series of additional videos and were asked to independently score each interaction using the protocol. Research assistants received certification when their overall interrater agreement exceeded 95%. This score indicated that the research assistant’s interpretation of the characteristic was consistent with the stated definition in our protocol, and the research assistant could then be allowed to observe in the field.

Measures of Child Outcomes

The second goal of our study was to measure the extent to which our educative curriculum might facilitate children’s word knowledge, conceptual development, and comprehension. We administered a battery of standardized and researcher-developed assessments. Children were individually assessed in a quiet area by a trained research assistant blind to the specific treatment group in two sessions at pretest and posttest. Assessments were administered in a set order across sessions.

Word Knowledge

Children’s word knowledge was assessed through two receptive tasks, one focusing on general receptive vocabulary knowledge and the other focusing on curriculum-related word knowledge.

General receptive vocabulary. Children's general vocabulary knowledge was measured with the PPVT-IV, a receptive vocabulary test that yields both raw scores and standard equivalent scores related to national norms (Dunn & Dunn, 2007). Standard scores were used for all analyses. The reported reliability for the PPVT-IV ranges from .93 to .95.

Curriculum-related word knowledge. We constructed a 48-item receptive vocabulary task to measure the number of vocabulary words children learned throughout the course of the intervention. Words were randomly selected from the corpora of target words taught throughout the four topics. Children were presented with a prompt (e.g., "Point to *bloom*") and asked to select the referent from among three photographs. These photographs included the referent (e.g., a flower bloom), a taxonomically related foil (e.g., a leaf), and a thematically related foil (e.g., a bee). Questions were randomized at pretest and posttest and then presented in a set order. Responses were scored dichotomously (i.e., correct or incorrect) and summed for a total score and percentages. Internal consistency was Cronbach's $\alpha = .78$. See the Appendix for the specific words assessed.

Conceptual Knowledge

Children's general conceptual knowledge was assessed through two tasks. Each task examined children's understanding of key concepts related to the topics taught in the WOW curriculum.

Yes/no. We created a 32-item task to assess children's conceptual understanding of target vocabulary for each topic. Children were asked to identify instances in which general conceptual properties could be applied (e.g., "Does a tree need food to grow?") or could not be applied (e.g., "Does a rock need food to grow?"). Each conceptual property was tested using both in-category and out-of-category target words. Questions were randomized and then presented in a set order; children heard an equal number of "yes" and "no" questions across the assessment. Responses were scored dichotomously (i.e., correct or incorrect) and summed to yield an overall score, which was then converted into a proportion score. Internal consistency was Cronbach's $\alpha = .62$.

Categorical property knowledge. To examine children's conceptual knowledge in greater depth, we constructed a 32-item receptive task to identify categories and category properties of target vocabulary words. Children were presented with a directive (e.g., "Point to the one that is a plant") and asked to select the referent from three photographs. These photographs included the correct referent (e.g., a sunflower), a referent thematically related to the target taxonomic category (e.g., topsoil), and a referent from a different taxonomic category (e.g., a grasshopper). Questions were randomized and then presented in a set order. Responses were scored dichotomously (i.e., correct or incorrect) and summed to yield an overall score (ranging from 0 to 32), which was then converted into a proportion score. Internal consistency was Cronbach's $\alpha = .85$.

Comprehension of Information Text

Given that the use of information text was a primary feature of the intervention, our final measure was designed to gauge how children comprehended these texts. To do this, we used two book-related tasks that were not part of the intervention.

Concepts of comprehension assessment. Children's understanding of informational text was assessed using an adapted version of the Concepts of Comprehension Assessment (Billman, Duke, & Hilden, 2008). Similar to our previous research (Mol & Neuman, 2014), in our adapted task children were read a 16-page illustrated informational text called *Salmon.* Throughout the book, they were asked to answer a series of comprehension questions about the information genre (e.g., "What types of things do you think this book will tell you?"), vocabulary (e.g., "This page teaches you a new word. What is that word?"), and understanding of the use of graphics in text (e.g., "Point to the picture that goes with the words I just read"). Internal consistency was Cronbach's $\alpha = .63$. Although this was below desirable levels, Gersten and his colleagues (Gersten, Fuchs, Compton, Coyne, Greenwood, & Innocenti, 2005) asserted that lower reliabilities can be considered acceptable for newly created measures and can indicate that a coherent construct is being assessed.

Responses were coded by trained research assistants who were blind to the study's hypotheses and were coded in accordance with the Concepts of Comprehension Assessment scoring guidelines (Billman et al., 2008). Correct responses received 2 points, partially correct scores received 1 point, and incorrect responses received 0 points. For example, in response to the first question, "What types of things do you think this book will tell you?" a child would receive 2 points if he or she said anything relevant to a salmon or a fish that would be found in an information book (e.g., "the life of salmon," "salmon eggs and streams"), 1 point if the response indicated a single word (e.g., "salmon," "fish," "the sea"), and 0 points if there was no response or an irrelevant response. Explicit criteria for responses—what was or was not acceptable—were listed in the scoring guide. Scores were summed to yield an overall score (ranging from 0 to 22), which was then converted into a proportion score. Intercoder agreement was 91.20%.

Comprehension of domain-specific text. Recognizing that informational texts vary according to the domain in which they are written ("Common Core State Standards for English Language Arts," 2010), in this measure we attempted to assess children's ability to use their developing knowledge network of science to comprehend and learn new information from a science-related text that included the core themes or big ideas that threaded throughout our intervention. In particular, we sought to understand children's ability to question, predict, analyze, and understand new information related to the topics in our intervention presented in a previously unfamiliar science informational book. To address this issue, we created a 12-page informational book titled *Ollie the Snowy Owl.* Illustrated with color photographs, the book described key characteristics of snowy owls, including physical properties, life cycle, habitat, and diet. The book's topic was selected to be consistent with the WOW curriculum (i.e., living things) while requiring children to explore and evaluate a new category exemplar (i.e., birds).

As the book was being read aloud to individual children, the assessor would intermittently stop and ask an open-ended question. These questions were designed to have children (a) observe and explore pictures in the text, (b) question and predict, (c) investigate, and (d) analyze and interpret. There were a total of 10 open-ended questions. For example, on the first page, the assessor would read, "Ollie, The Snowy Owl lives in a place called the Arctic tundra. What can you observe about Ollie's habitat?" In response, a child might say, "It looks like it's winter" or "I wonder how Ollie can keep warm." Responses to each question were recorded and transcribed. Because of the wide variation of responses, items were scored dichotomously (i.e., correct or incorrect): If the response seemed to reasonably relate to the topic, the item was scored correct; if it was unrelated to the picture or text, it was scored as incorrect. Scores were summed and converted into a proportion score. A second research assistant independently coded responses for 25% of the sample. Intercoder agreement was 96%.

Procedures

One week prior to implementation, teachers in the treatment group participated in a full-day professional development session led by the project team. In this session, we provided the rationale, materials, and procedures for the intervention. Teachers were also introduced to the instructional design and the educative features of the materials. Specifically, we described each feature and the ways it might be used during the enactment of the curriculum. For example, we suggested how some of the prompts might help teachers understand the types of responses and queries that might especially enhance children's vocabulary, the ways in which these responses might be used to develop more generic understandings of key concepts, and strategies that might support those children who may need additional instruction.

The intervention began in September and lasted for 12 weeks. Sessions were designed to take between 12 and 15 min daily and typically replaced a portion of the whole-group time. Comparison teachers in the control group, in contrast, engaged in business-as-usual activities, selecting their own books and engaging in their typical reading strategies.

Fidelity of Implementation

We created a fidelity tool to capture teachers' enactment of the intervention as well as the extent to which they engaged in the intervention as intended. Content coverage included whether each part of the lesson was delivered (i.e., video clip, information book, picture cards, time for a challenge, discussion). Quality features included whether the lesson was well paced, engaging, and facilitative of discussion and whether teachers were responsive to children's comments and questions. Prior to the beginning of the study, three research assistants were trained using a detailed description of the implementation checklist. Each checklist was reviewed, and videotaped examples were reviewed. Research assistants were then asked to watch master-coded video recordings and independently score each one using the checklist. Research assistants received certification when their overall agreement exceeded 95%.

Over the course of the study, research assistants visited treatment classrooms on a weekly basis and observed the WOW lesson for fidelity. Each element of the lesson was scored dichotomously as either present or absent. Average fidelity was 87.89% (range = 85%–90%) across teachers. In addition, we measured the quality of implementation. Research assistants were asked to provide a holistic score using a detailed rubric (e.g., "information book was read in a high-quality manner"). Features were scored on a 4-point Likert scale ranging from *strongly disagree* to *strongly agree*. The average quality of enacted features was 3.05 ($SD = .34$) across teachers, suggesting, for the most part, high-quality implementation. Differences in quality of implementation varied considerably across teachers, indicating no discernible pattern.

During the study, we randomly selected 15% of observations to be videotaped and independently coded by a second research assistant. Intercoder agreement was 98.33% for the dichotomous measure and 64.81% for the holistic rating scale.

Observation of Teacher Language

Using our Likert scale, we observed teachers' talk in treatment and control classrooms prior to and on three occasions during the intervention. During each 10-min observation, the research assistant would sit in an unobtrusive location, take notes, and record the teacher's talk. Following the observation, the research assistant would then code each characteristic of the teacher's talk holistically using the detailed rubric described previously. When selecting an appropriate rating, the research assistant was trained to first choose whether the construct was "characteristic" (i.e., 3 or 4 rating) or "not characteristic" (i.e., 1 or 2 rating) and then make finer distinctions between each, using the recording if necessary. Approximately 25% of classroom observations were videotaped, and teacher language was independently scored by a second research assistant. Interrater agreement was 95.20%.

RESULTS

The goal of our research was to examine the effect of our educative intervention on teachers' child-directed language and subsequent child outcomes. To do so, we first describe the various components of teachers' talk and examine the relationships among its features. Next we examine the influence of the educative intervention on teachers' use of cognitively demanding language, comparing teacher talk across treatment and control groups. We then report the impact of the intervention on child outcomes.

The Qualities of Teacher Talk

Table 3 describes the relationship among lexical features of teachers' talk and the cognitive demand of their talk. As shown, lexical features were highly correlated. Quality and variety of teachers' talk, and teachers' use of paraphrasing and repetition with children, were highly

TABLE 3
Correlation Matrix for Teacher Language Variables

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Lexical richness										
1. Quantity of language	—									
2. Variety and sophistication	.96**	—								
3. Repetition and paraphrasing	.96**	.95**	—							
Cognitively demanding and challenging										
4. Conceptual questioning	.89**	.88**	.92**	—						
5. Bridging	.72*	.80**	.77*	.65	—					
6. Categorization	.72*	.81**	.82**	.81**	.70*	—				
7. Definitions	.90**	.93**	.89**	.74*	.78*	.77*	—			
8. Generic noun phrases	.61	.66	.71*	.69*	.77*	.85**	.67*	—		
9. Causal reasoning	.77*	.86**	.80*	.57	.82**	.71*	.93**	.57	—	
10. Metacognition	.86**	.85**	.91**	.72*	.73*	.72*	.81**	.69*	.79*	—

*$p < .05$. **$p < .01$.

intercorrelated, suggesting a construct of linguistic features in teachers' talk. However, there was greater variation among the characteristics associated with the cognitive demand of teacher talk. Conceptual questioning (related to Sigel's, 1982, notion of distancing), child-friendly definitions, and metacognition appeared more highly related than the other cognitively challenging variables frequently described in the literature.

We next examined the means and standard deviations of these teacher talk characteristics prior to and during the intervention period, 4 weeks after its implementation. In order to test the differences between groups, and for the purposes of clarity, we conducted separate independent *t* tests for each dependent variable before conducting more complex tests. This was done to determine any initial differences between groups in the characteristics of teacher talk prior to the intervention. Multiple tests like this can increase the family-wise error rate, and any potential significant differences for these *t* tests should be interpreted with caution. However, even with this potential for an increase in Type I error, as shown in Table 4, there were no significant differences between groups prior to the treatment period. Before treatment, the lexical features of quality, variety, and paraphrasing in teachers' talk were somewhat characteristic in their exchanges with children in both groups. By contrast, the features of cognitively challenging language were for the most part not characteristic in either group.

This pattern changed significantly during the intervention period. As shown in Table 4, during the enactment of the curriculum, the lexical features of teacher talk increased significantly. The quality, variety, and sophistication of teachers' child-directed language during the intervention were considered characteristic of treatment teachers' interactions with children compared to the rather stable pattern of talk among teachers in the control group. This pattern was less consistent with the cognitively challenging talk. Here, the curriculum appeared to influence treatment teachers' conceptual questioning, their use of child-friendly definitions, and their use of causal reasoning in their talk. However, with the exception of conceptual questioning, which reached characteristic, these other two factors only increased to somewhat

TABLE 4
Means (*SD*) for the Teacher Language Variables (Maximum Score = 4)

	Prior to intervention		*During intervention*	
Variable	*Treatment*	*Control*	*Treatment*	*Control*
Lexical richness				
Quantity of language	2.25 (0.96)	2.50 (1.0)	3.20 (1.00)***	1.75 (0.50)
Variety and sophistication	1.75 (0.50)	2.25 (0.96)	3.20 (1.42)**	2.00 (0.82)
Repetition and paraphrasing	2.00 (1.15)	2.00 (0.00)	3.00 (0.00)*	2.25 (0.82)
Cognitively demanding and challenging				
Conceptual questioning	1.75 (0.50)	2.00 (0.82)	3.00 (0.00)***	2.00 (0.82)
Bridging	1.33 (0.58)	1.50 (1.0)	1.60 (0.55)	1.25 (0.50)
Categorization	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.25 (0.50)
Definitions	1.75 (0.96)	2.25 (0.96)	2.80 (0.44)*	1.50 (0.58)
Generic noun phrases	1.50 (1.0)	1.25 (0.50)	1.60 (0.55)	1.00 (0.00)
Causal reasoning	1.00 (0.00)	1.00 (0.00)	2.00 (0.71)*	1.25 (0.50)
Metacognition	1.00 (0.00)	1.25 (0.50)	1.60 (0.55)	1.25 (0.50)

*$p < .05$. **$p < .01$. ***$p < .001$.

characteristic or slightly higher. Other variables, such as bridging, categorization, use of generic nouns and properties, and metacognition, remained flat during the intervention.

Next we conducted principal component analysis (PCA) for the two types of teacher language. The major goal of PCA is to reveal the hidden structure in a data set, to compress multiple variables in such a way as to reduce redundancy in order to find a smaller set of linear combinations of covariates that are uncorrelated with one another. It is often used to avoid the problem of multicollinearity, the undesirable situation when the correlations among the independent variables are strong. Weighing all three factors equally, we found that the components of lexical richness accounted for 97.00% of the variance. We conducted a similar analysis for cognitively challenging talk. Giving equal weight to all seven variables in the PCA, we found that the cognitively challenging components accounted for 77.59% of the variance. As expected, the characteristics of teacher talk fell into the two categories indicated in Table 4.

We then generated two composites, representing lexical richness and cognitively challenging language, by calculating z scores for the variables under each category, multiplying each teacher's score by the corresponding factor loading, and then summing these scores. When we examined the differences between groups, independent-samples t tests revealed that teachers in the treatment group had significantly higher lexical richness composite scores than teachers in the control group, $t(7) = 2.54$, $p = .039$. The effect size was substantial (Cohen's $d = 1.92$). These results suggest that the educative curriculum facilitated teachers' enactment of lexically rich language. Similarly, teachers in the treatment group showed significantly higher cognitively challenging scores than teachers in the control group, $t(7) = 3.49$, $p = .010$. This effect was substantial (Cohen's $d = 2.63$), indicating that the curriculum appeared to promote teachers' use of cognitively challenging talk. Collectively, these results suggest that the curriculum changed the dynamic of teacher talk, enhancing the quality and challenge of the interactions with children.

Influence on Outcomes

Our next analysis was to examine the effects of the educative curriculum on child outcomes. We first analyzed the correlations between our conceptual (i.e., conceptual and categorical knowledge) and our comprehension (i.e., concepts of comprehension and comprehension of domain-specific text) measures. Because of the high level of correlation between measures ($r = .42$, $p < .001$, for concepts; $r = .43$, $p < .001$, for comprehension), we created composite measures for concepts and comprehension. Cronbach's alphas were .73 for the new concepts and categories composite measure and .73 for the comprehension measure.

Next, because of the multilevel nature of the data we used two-level hierarchical linear modeling (HLM) with the treatment condition at the classroom level for our analyses. Although our number of clusters was relatively small (11), it met the minimum requirements for mixed model analyses (Maas & Hox, 2005). These analyses are more conservative than individual analyses, as they recognize that children are not independent from one another but are clustered within classrooms. HLM permits the partitioning of variance between students and between classrooms.

For each outcome measure, we first determined whether there was statistically significant variability between teachers and calculated the intraclass correlation (ICC), or the amount of variance in the outcome that existed between students and between classrooms. Preliminary estimation of an empty model with a random intercept and classroom as the grouping variable revealed significant ICCs among classrooms for curriculum-related word knowledge (.15) and conceptual knowledge (.29). The ICCs were not statistically significant, however, for the comprehension composite measure (.01). These results indicated that individual analysis with this measure would be more appropriate than HLM. Taken collectively, these findings suggested that a model with a random intercept better fit our data than a model that did not allow for random variability. Because there was no significant difference between groups at pretest (see below) we did not include time as a variable in the HLM model. We examined each of the independent variables (condition, lexically rich teacher language, and cognitively challenging teacher language) separately for each of our outcome variables.

Pre- and posttest means and standard deviations for the child outcome measures are reported in Table 5. As shown in Table 5, PPVT scores remained stable throughout the intervention period. At pretest, there were no statistically significant differences between the treatment and control groups, $F(1, 12.55) = 0.51$, $p = .489$. Similarly, there were no significant differences between the groups after we controlled for pretest scores following the intervention, $F(1, 108) = 0.2$, $p = .655$. These results were anticipated given the brevity of the intervention.

However, this was not the case with the more proximal measures of child outcomes. Pretest scores on the curriculum-related word knowledge measure between treatment and control groups were not significantly different, $F(1, 9.08) = 1.88$, $p = .203$. Controlling for pretest scores, the HLM analysis revealed significant differences in curriculum-related word knowledge between the treatment and control groups following the intervention, $F(1, 111) = 28.41$, $p < .001$. Table 6 shows the model specifications for these analyses, with rows indicating outcome variables and columns indicating independent variables entered separately.

A similar pattern was reported with conceptual development. Children's pretest scores on the conceptual knowledge composite measure revealed no significant differences between the treatment and control groups at pretest, $F(1, 7.39) = 3.39$, $p = .107$. After the intervention, controlling for pretest scores, HLM analyses revealed significant differences between groups. The treatment group demonstrated significantly greater conceptual understanding compared to the control group, $F(1, 9.31) = 11.20$, $p = .008$. Collectively, these results suggest that children acquired substantial conceptual knowledge through their experiences with the curriculum.

Next we examined children's performance on the comprehension composite measure. Because this composite had a nonsignificant ICC and no pretest measures, we controlled for

TABLE 5
Comparisons of Pre- and Posttest Scores on Child Outcome Measures
(Proportion Correct Except Where Noted)

	Treatment		*Control*	
Assessment	*Pretest*	*Posttest*	*Pretest*	*Posttest*
General receptive vocabulary (PPVT)	99.96 (13.38)	101.47 (14.18)	97.9 (15.62)	99.96 (13.33)
Curriculum-related word knowledge	.57 (.10)	.70 (.10)[a]	.54 (.12)	.60 (.11)[a]
Conceptual knowledge	.62 (.09)	.72 (.11)[a]	.59 (.11)	.60 (.12)[a]
Comprehension	—[b]	.37 (.15)[a]	—[b]	.27 (.14)[a]

Note. Data are *M* (*SD*). PPVT = Peabody Picture Vocabulary Test–IV (Dunn & Dunn, 2007).
[a]Significant differences between treatment and control groups ($p < .05$). [b]Assessment was not administered at pretest.

TABLE 6
Model Specifications of Multilevel Analyses for Models With Independent Variables Entered Alone (Controlling for Pretest Scores)

	Condition		*Lexically rich teacher language*		*Cognitively challenging teacher language*	
Variable	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*
General receptive vocabulary (PPVT)	.91	2.04	.10	0.26	.09	0.15
Curriculum-related word knowledge	.07**	0.01	.01*	0.004	.01*	0.002
Conceptual knowledge	.10**	0.03	.02*	0.004	.01*	0.002

Note. All coefficient estimates are unstandardized. PPVT = Peabody Picture Vocabulary Test–IV (Dunn & Dunn, 2007).
$^{*}p < .05$. $^{**}p < .01$.

children's initial receptive language (i.e., pretest PPVT scores) and conducted an analysis of covariance to examine differences in performance between the treatment and control groups. We found significant differences in the treatment and control groups' performance on the comprehension measures at posttest, $F(1, 109) = 9.94$, $p = .002$, Cohen's $d = .69$. These results suggest that the educative curriculum enhanced children's understanding of the text features and the domain-specific knowledge in science-related information texts. See Table 6 for model specifications of multilevel analyses for all outcome variables.

Together, our findings indicate that children in the treatment group significantly improved their word knowledge and conceptual understandings as a result of the curriculum. In addition, these children appeared to develop greater comprehension of information text, specifically science-related text.

DISCUSSION

Previous trials of the WOW, a supplemental vocabulary intervention, have reported positive results on children's vocabulary, concepts, and comprehension. These trials relied on extensive coaching and support to enhance the quality of teacher talk and teachers' use of cognitively challenging language. In the study reported here, our goal was to examine whether a curriculum that included educative features for teacher development could potentially improve teacher talk and subsequently children's skills without such ongoing support. The purpose of our study therefore was to support teachers' child-directed language and student outcomes by enhancing the educative features of an intervention targeted to vocabulary and concept development. In contrast to a typical teacher guide, an educative curriculum offers support for teaching in thinking about content beyond the level suggested for students and by making more transparent the instructional design or underlying pedagogy of the curriculum (Davis & Krajcik, 2005). In this study, we added five features based on a set of established design heuristics to provide teachers with both knowledge about living things in science and the disciplinary practices around children's language development. Given the importance of teacher talk in children's vocabulary development and the paucity of high-quality talk reported in previous studies (Wright & Neuman, 2014), we attempted to guide teachers more deliberately in thinking about and using cognitively challenging talk throughout the enactment of the curriculum.

Results of our study showed strong support for improvements in the quality of teachers' talk in the treatment group compared to the control group. The educative curriculum appeared to enhance both the quality and cognitively challenging nature of teachers' interactions with children. Although not every variable measured improved during the intervention, an effect likely due to the relatively small sample size or the relatively brief duration of the intervention, teachers characteristically engaged in more lexically rich and cognitively challenging talk than they did prior to the intervention; effect sizes for both types of talk indicated that these improvements were practically meaningful and substantial. These results suggest that a curriculum intentionally designed to enhance teachers' talk can provide an important support for improving the quality of instruction.

In turn, children in the treatment group clearly benefited from the instruction. As a result of the intervention, word knowledge, conceptual and categorical development, and comprehension improved significantly over the course of the intervention, with effect sizes ranging from modest to strong. We recognize that, given our design, it would be impossible to attribute these gains specifically to the improvements in teacher talk. However, at the same time, the results do suggest that the quality of teacher talk and the quality of instructional enactment may be inextricably connected. For example, the language of instruction in preschool is primarily oral, and the quality of extratextual talk that accompanies shared book reading has been shown to play a significant role in children's language development, especially in the early childhood years (Price et al., 2012; Price, van Kleeck, & Huberty, 2009).

Similarly, we cannot argue that it was the educative features of the curriculum rather than the curriculum alone that led to improvements in teacher talk and child outcomes. Unfortunately, given the number of classrooms in the study, the power to detect differences in children's outcomes would have been significantly reduced if we had randomly selected children into three groups (i.e., the educative curriculum, the curriculum alone, and a control group). This is a significant limitation of the study. At the same time, we can report that the child outcomes obtained in this study replicated those in our previous studies, which provided ongoing weekly coaching to teachers. Consequently, the findings suggest that, although certainly not a replacement for professional development, the educative curriculum might play a role in enhancing the day-to-day enactment of the curriculum, refreshing teachers' knowledge and meshing both content and pedagogical knowledge. We are now conducting in-depth interviews with teachers in a subsequent study to examine their reactions to the educative components in the curriculum.

Nonetheless, we recognize a number of limitations to our analytic efforts in this study. The most significant is that some of our assessments had marginal reliability. Although Gersten and his colleagues (2005) have asserted that lower reliabilities can be considered acceptable for newly created measures and can indicate that a coherent construct is being assessed, reliabilities were clearly below desirable levels. In our future research, we intend to refine and further develop our content-specific measures. Only second to this limitation is the intervention's brief duration of 12 weeks, as well as its focus on only one aspect of science learning, living things. Children were engaged in learning about a topic that is typically of high interest. Therefore, we cannot assume that these relationships will generalize to other science topics and the requisite technical vocabulary and concepts in those areas. Lastly, although presumably both treatment and control groups were trained in promoting cognitively challenging talk involved in daily science and literacy activities through their core curriculum, it is clear that our measures were more closely aligned with the intervention's targeted focus; we cannot assume that the intervention improves early literacy skills or science more globally.

Despite calls for reform in curriculum materials, this study represents one of the few that has examined the role of educative curricula. Previous studies in science education (e.g., Schneider & Krajcik, 2002) have reported that educative curriculum materials were most helpful in planning instruction and focusing on what teachers would need to know to enact a lesson successfully with students. Observational data in a small-scale study indicated that teachers' practices were more consistent from classroom to classroom than in their previous trials. Others (e.g., Drake, Land, & Tyminski, 2014) have found that these educative features are particularly useful for preparing novice and less experienced teachers, particularly in highlighting new strategies they can use to support students' construction of knowledge and to understand students' thinking about the domain.

In early childhood, educative materials might be particularly useful for teachers who lack strong background knowledge in science education and/or language development (Zaslow & Martinez-Beck, 2006). In our case, for example, none of the teachers had received professional development in recent years, mostly because of declines in state funding. Furthermore, although all teachers could recall having taken curriculum pedagogy courses in their training, and, in some cases, language and literacy courses, the relation between these courses and the contexts of their classroom and children's learning seemed far removed. In contrast, educative materials may be more uniquely situated to classroom practice. Because they deal with the actual enactment of the lesson, they appear to support the simultaneous goals of enhancing content and pedagogy in the teacher's actual classroom. This is reinforced by the relatively high fidelity to both the content and the quality of the treatment that was evident throughout our study.

We recognize that this is an initial step in our analysis of the potential of educative curriculum in improving teacher knowledge and practice. Therefore, although we have gained some important insights, there are many additional questions to be raised. Specifically, it will be important to qualitatively understand how teachers are using the educative features of the curriculum and whether the curriculum is reaching its intended goal. For materials to be truly educative, for example, they will need to not only enhance the quality of the enactment of a curriculum—which is no doubt important—but also improve teacher learning more deeply. This means applying knowledge in real-time practice to make instructional decisions, participating in the discourse of teaching, and engaging in a range of high-leverage practices that are aligned with children's learning and development (Ball & Forzani, 2011). This suggests that a truly educative curriculum should have spillover effects to other areas outside the particular curriculum and its enactment. Subsequent research should examine the degree to which practices developed within a curriculum have the potential to support other areas. In the case of the present study, the question would include whether teachers engage in cognitively rich language outside of a curriculum in daily activities and whether they intentionally promote children's oral language development through their comments and their questions.

In conclusion, educative curricula appear to be a promising approach to facilitating teacher learning and student learning. However, there is much research that needs to be conducted. For example, to date there is little empirical evidence to guide the development of such materials. In this study, we based our work on our understanding of noted roadblocks and issues in teachers' previous engagement with our curriculum and attempted to integrate these features with the design heuristics suggested by Davis and Krajcik (2005). At the same time, however, it is unclear whether these particular features could be generalized to other curriculum materials. Further research is needed that examines the prerequisite skills or knowledge early childhood teachers need and how this may influence children's learning. This research will inform the further development of materials that potentially support and bootstrap learning for teachers as well as students.

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APPENDIX

RTL.WOW.Labels.Test1 Child's Number ____________________
Assessor ID____ Date of Testing__________

WOW Labels Testing Form 1

Step 4: Test Items (NO FEEDBACK, NO DISCONTINUE)
Read each prompt and circle the label for the picture that the child points to. Do not worry about whether the child's response is correct.

SAY: ***"Point to …"***

	Prompt	Picture 1	Picture 2	Picture 3
1	**SHOULDER**	Knees	Shoulder	Jacket
2	**BOUQUET**	Bouquet	Vase	Shrub
3	**THORAX**	Thorax	Magnifying glass	Head
4	**DOLPHIN**	Seal	Bay	Dolphin
5	**SKELETON**	Man	Skeleton	Pumpkin
6	**MARINE**	Fisherman	Marine	Desert
7	**BARK**	Bark	Leaves	Squirrel
8	**MUSCLES**	Bench press	Muscles	Hair
9	**EYEBROWS**	Ear	Eyebrows	Eyeglasses
10	**STEM**	Watering can	Stem	Petal
11	**KATYDID**	Green leaves	Katydid	Ladybug
12	**SEA OTTER**	Tide pool	Walrus	Sea otter
13	**ABDOMEN**	Foot	Abdomen	Jacket
14	**HIVE**	Flowers	Anthill	Hive
15	**GRASPING**	Crayon	Grasping	Clapping
16	**MOTH**	Moth	Butterfly net	Grasshopper
17	**ANKLE**	Ankle	Hand	Sock
18	**CAMOUFLAGE**	Camouflage	Sting	Visible insect
19	**BLOOM**	Bee	Bloom	Leaf
20	**BEE**	Honey	Fly	Bee
21	**DESERT**	Desert	Sun	Jungle
22	**TORSO**	Shirt	Torso	Legs
23	**WINGS**	Antennae	Wings	Kite
24	**KRILL**	Kelp	Coral	Krill
25	**TOPSOIL**	Shovel	Grass	Topsoil
26	**ANT**	Katydid	Ant	Anthill
27	**FOREHEAD**	Forehead	Hat	Chin
28	**BLOWHOLE**	Fin	Blowhole	Mouth

RTL.WOW.Labels.Test1 Child's Number ______________________
Assessor ID____ Date of Testing__________

29	**ELBOW**	Sweater	Knees	Elbow
30	**LUNGS**	Dandelion	Stomach	Lungs
31	**ROOTS**	Garden hose	Spines	Roots
32	**FIN**	Snorkeling	Fin	Tail
33	**ANTENNAE**	Legs	Ear	Antennae
34	**LARVAE**	Eggs	Larvae	Earthworm
35	**WEEDS**	Garden trowel	Weeds	Trees
36	**POLLEN**	Seedling	Pollen	Sneezing
37	**WHALE**	Manatee	Whale	Boat
38	**CHRYSALIS**	Larva	Chrysalis	Seedling
39	**SAPLING**	Sapling	Tree	Seal pup
40	**MOIST**	Dry	Moist	Umbrella
41	**AQUARIUM**	Aquarium	Museum	Beach
42	**WALRUS**	Walrus	Dolphin	Elephant tusks
43	**PRAYING MANTIS**	Leaves	Praying mantis	Grasshopper
44	**BRAIN**	Hat	Heart	Brain
45	**MANATEE**	Fish	Manatee	Sea lion
46	**SEEDS**	Insect eggs	Seeds	Fruit
47	**BAY**	Canyon	Lighthouse	Bay
48	**MAMMAL**	Milk	Reptile	Mammal