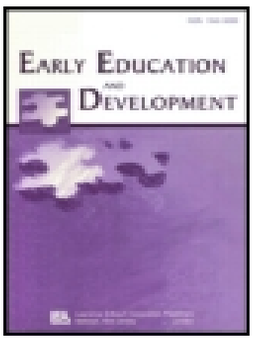

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Enacting Content-rich Curriculum in Early Childhood: The Role of Teacher Knowledge and Pedagogy

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ABSTRACT

Research Findings. This study examines the complexities of enacting an explicit content-rich curriculum in a large urban school district. Thirty-six teachers from 12 elementary schools, preK through Grade 1 were recruited to teach the *World of Words*, an integrated science and literacy supplementary curriculum. Prior to the start of the study, teachers completed two self-reported surveys on their knowledge of science and pedagogical practices; their classroom lessons were subsequently audiotaped after several weeks of instruction. Results indicated that despite explicit guidance in the curriculum to engage in higher-order questioning, teachers' questions and comments remain strikingly low-level (63%). Subsequent case studies of four teachers, contrasting high or low levels of content knowledge and pedagogy showed that the higher content *and* pedagogy teacher engaged more successfully in enacting the curriculum with integrity. These results suggest the need for greater attention to teachers' content knowledge and applications to practice in professional development. *Practice or Policy*. Findings provide suggestive evidence for a greater emphasis on the integration of domain-specific content and pedagogy in teacher professional development, if we are to support high-quality implementation of content-rich curriculum.

Research has consistently shown the importance of immersing young children in language- and content-rich instruction (Cervetti et al., 2012; Neuman & Kaefer, 2018). Numerous studies have found that integrating science with disciplinary language and literacy skills in curriculum promotes both science learning and science-related discourse (Gonzalez et al., 2011; Wright & Gotwals, 2017). Nevertheless, simply providing teachers with curriculum materials, even those of high quality, does not ensure that they meet the intended learning outcomes for children. Rather, high-quality teaching is thought to require the concomitant management of several different resources for teachers, including their content knowledge, attitudes, and their understanding of the pedagogical instructional practices that might support children's learning (Ball & Cohen, 1999; Hill & Charalambous, 2012; Saçkes et al., 2011).

However, despite the now wide-spread consensus that the work of teaching requires both content and pedagogy, it is striking how rare such integration occurs in many professional development programs (Williams et al., 2009). Studies examining changes in teachers' talk and classroom discussion from in-service training programs have largely overlooked the content in which these activities take place (Bowne et al., 2016; Dwyer et al., 2016; Michener et al., 2018). Teachers are encouraged to ask higher-order questions in texts that may call upon children's reasoning skills without the requisite background knowledge in which to make informative responses. Asking kindergartners how sharks and whales might be different, for example, a higher-level question than one of simple

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recitation, not only requires teachers' pedagogical knowledge, but also content knowledge to help children engage in clarifying and extending interesting discussions.

This focus on improving the quality of content-rich instruction has arisen, at least in part, because of evidence suggesting that wide disparities in educational experiences continue to plague U.S. schools, with traditionally marginalized students receiving less rigorous curriculum compared to their peers (Allington & Woodside-Jiron, 1999; Duncan & Murnane, 2011). Providing purposeful instructional and educational opportunities, especially for low-income children who may come from environments with limited access to print media is essential to facilitate later learning and comprehension of more complex text (Neuman & Celano, 2012). Gonzalez et al. (2011), for example, reported statistically and practically significant effects of the WORLD intervention on standardized language measures (d = 1.41) for low-income preschoolers' social studies and science vocabulary. Furthermore, recent research reports and policy documents (Chiefs for Change, 2017; Chingos & Whitehurst, 2012) reinforce the importance of engaging children in knowledge-building curriculum experiences that develop language and vocabulary in the content area (e.g., social studies; science). These and other studies (Pollard-Durodola et al., 2016) suggest that children who have access to high-quality content-rich curriculum are well positioned for academic success in elementary school and beyond.

Therefore, high-quality curriculum materials that encompass a program of instruction, clearly defined sequence of experiences, and a recommended pedagogy can certainly aide in instruction. However, clearly, there are limitations in relying on them. Materials on their own cannot help teachers go below the surface to explore ideas in depth, to respond to children's queries in ways that deepen their understanding, or to anticipate and correct any potential misconceptions (Hill & Charalambous, 2012). Even the most sophisticated educative curriculum materials, those designed with the intention of promoting teacher learning may fall short in their efforts to scaffold teachers' pedagogical strategies and content knowledge (Davis et al., 2014; Schneider & Krajcik, 2002). For example, in these studies Davis et al. (2014) found that the uptake of support by teachers from the educative curriculum in science was far greater for scientific *practices* than their uptake of support for scientific *content*.

Rather, in order for teachers to effectively translate a knowledge-rich curriculum for children into a curriculum which adheres to the program's principles, it is reasonable to assume that they, too, will need content-rich professional development. In contrast to generic teaching techniques in professional development, they are likely to need discipline-specific knowledge and strategies to convey concepts and big ideas in developmentally appropriate and effective ways. For example, in an integrated language and science curriculum, teachers will likely engage children in learning about the differences between living and nonliving things, life cycles, physical changes in the earth and sky, the property of matter and changes in materials (e.g., solids, gases), as well as strategies to guide children's scientific inquiry of the underlying science concepts. Hill et al. (2005) describe such competency as "subject-matter knowledge for teaching," (p. 372) highlighting the joint contribution of teachers' understanding and use of subject-matter knowledge to carry out the tasks of teaching.

Subject-matter knowledge for teaching not only captures the credit hours or workshops in a particular content area, such as science, that a teacher might have earned; it also reflects teachers' dispositions toward the subject matter, their confidence, and beliefs about their ability to teach it (Ball & Forzani, 2011; Hill & Charalambous, 2012; Hill et al., 2005). At the same time, in the case of early childhood, teachers must be aware of how to convey this knowledge in developmentally appropriate ways (Neuman et al., 2000); to understand that young children might need additional supports (e.g., hands-on experience; explicit definitions; clarifying language interactions; pictorial/gestural support) to foster conceptual understanding and decontextualized word meanings in the content area.

Furthermore, since many curriculum materials include book reading as an instructional feature in learning about language and content, teachers will need to understand how the book itself, its genre and features, might affect the quality and interactions between teachers and children. Studies by

Price and her colleagues (Price et al., 2012) have shown that books written with the purpose of providing more scientific types of information about a topic (e.g., narrative nonfiction; expository) may affect the quality of interactions between teachers and children. For example, although highly engaging, predictable books which encourage chiming and repetition of known sequences may not support the type of higher-level questioning that engages children in comprehension of content and conceptual understanding. Therefore, knowing how to select and use content-rich text is essential to support deeper interactions that allow children to recall, integrate, and extend their knowledge and inferential thinking (Cervetti et al., 2016).

Consequently, there are multiple domains of teacher knowledge and practice that must support the implementation of curriculum. From the perspective of implementation science (Bryk, 2016), it will require more than fidelity to the curriculum (e.g., follow the program as it is written). Rather, it will need to address the integrity of its implementation (e.g., use the program in ways that reflect its intention while accommodating to local circumstances; LeMahieu, 2011). Nevertheless, to date, the educational policy arena has been dominated by standards-based reform (National Governors Association Center for Best Practices and Chief State School Officers, 2010), the notion that high academic standards aligned with a content-rich curriculum will enable students to become career and college-ready. Unfortunately, missing from this equation between rigorous standards and rigorous instruction is the educative preparedness of teachers, and their ability to implement a program that is true to the intention of the curriculum design. Too often, teachers vary considerably in the way in which they may use materials, with some following the guidance from teachers' manuals while others more likely to cover materials selectively (Chingos & Whitehurst, 2012). Such variation across settings has led Cohen and Mehta (2017) to lament that "giving each and every student an engaging and intellectually ambitious curriculum is the most difficult task reformers have attempted and the one that they have had the least success in the mainstream" (p. 677).

This paper highlights the complexities of implementation and teachers' subject-matter knowledge for teaching through the lens of scaling up an explicit curriculum in a large urban school district. These data for this analysis come from a larger study that has investigated the effects of an integrated science and vocabulary supplemental shared book reading curriculum designed to improve preschool through first grade children's word and science-related concepts. Prior to the start of the study, all of the teachers had participated in a traditional one-day workshop, highlighting the theory and practices of the curriculum. As the year progressed, however, we began to notice differences in the teachers' implementation of the program, differences that could not be attributed to fidelity (which was universally high), but more to the integrity and consistency of the program in relation to its original design principles.

From this viewpoint, we began to conduct more detailed observations of four teachers to understand these differences. We questioned whether different domains of teacher knowledge (e.g., content, pedagogy, and text) might contribute to the implementation of the program. Did their confidence in the subject matter and/or their knowledge of literacy-related pedagogical techniques affect their practice?

To address these questions in this study we describe two sets of analyses. In this first analysis, we examine 36 teachers' extra-textual talk during the shared book read-aloud portion of the program in preK through grade 1. Based on this analysis, and to better understand these patterns, we then report on a second analysis, an exploratory set of case studies of teachers, each teaching the same or similar content. Across these cases, teachers' subject-matter expertise as well as their subject-matter knowledge for teaching differed, exemplifying the kinds of variation in teacher knowledge one might find in professional settings. In highlighting these variations, we argue that teacher content knowledge may be an under-represented factor in the implementation of curriculum in early childhood. And in recognizing these realities, these findings have important implications for professional development if we are to effectively implement and scale-up a content-rich curriculum with integrity.

Background: The Collaborating District

We began our collaboration in a district serving over 125,000 children within a large urban school system in 2015. Our goal was to improve children's oral language, and academic achievement in the early years, prekindergarten through grade 1 in "priority" schools, a state designation indicating its lack of progress in academic performance. The district served families who struggled with poverty; over 90% of the children received free and reduced lunch. Almost half of the children were Hispanic/Latino; 22% African-American and 16% Multi-racial and other ethnicities. The teachers in the district tended to mirror the child demographics: 46% of the elementary teachers identified as Hispanic/Latino; 21% Black/African American; 30% Multi-racial; 3% Asian and 1% White.

The larger urban school system was known for local control; that is, under the principal's guidance, each school within a district could select its own curriculum as long as it conformed to the adopted standards (e.g., aligned with Common Core). Given the mobility of families that has traditionally plagued many high poverty communities, however, the district superintendent sought to create a district-wide initiative in early childhood to enhance academic language. Twelve schools and 36 classrooms signed on to participate in the program, with expansion plans to all 17 elementary schools and all early childhood classrooms at some later point in the following year.

The Explicit Instructional Program

Known as the *World of Words (WOW)* (Neuman et al., 2016), the program is a shared book reading supplementary curriculum designed to promote vocabulary and content knowledge in science. Structurally, the year-long curriculum is organized by topics, 3-weeks in length, that represent animate taxonomies in life, earth, and physical sciences aligned with the Next Generation Science standards. Within the curriculum, words are selected that represent content-rich vocabulary within the category structure of the topic (e.g., plants; stem, leaf, roots). Previous trials have demonstrated positive evidence on children's science-related vocabulary, conceptual knowledge, and comprehension skills, with a reported average effect size of d =.65 (Neuman & Dwyer, 2011; Neuman & Kaefer, 2013, 2018; Neuman et al., 2011) in comparison with control conditions.

The curriculum provides multiple levels of support to teachers to enhance meaning-making, to build children's background knowledge in the context of a conceptual framework, and to help organize knowledge in ways that facilitates retrieval and application. For example, it includes an instructional guide for teachers, and an explicit pedagogy for delivering instruction. It also includes educative features throughout the guide designed to support teacher learning (Davis et al., 2014) indicated by color-coded panels throughout each topic. Aligned with the National Research Council's seminal work, *How People Learn* (Bransford et al., 2000), and the more recent policy recommendations by a number of top-ranking district and state education leaders (Chiefs for Change, 2017), the curriculum is designed to be content-rich, standards-aligned and explicit – characteristics assumed to exert a powerful influence on children's achievement (Foorman et al., 2016).

Initial Implementation in the District

With these previous trials behind us, we approached the scale-up of our intervention to a new district with substantial evidence of its effects. Nevertheless, although evidence from field trials may indicate that an intervention *can* work, Bryk and his colleagues (Bryk et al., 2015) caution that they do not necessarily indicate that they *will* work reliably in a very different context. Implementation science often requires *adaptive integration* to better understand the affordances and the potential challenges of the new setting, and what it might take to accomplish such goals. Therefore, in our first analysis, we addressed the following questions:

- Does the use of an explicit, prescribed curriculum lead to a greater consistency of instruction (e.g., fidelity) within and across grade levels?
- Does its enactment support teachers' use of higher-order questions? This question addresses the integrity in implementation, and its relation to improvements in practice (Bryk, 2016).

Sample

Schools were recruited in the spring of 2015. Principals from 12 elementary schools volunteered to participate in the project; they, in turn, selected three classroom teachers, one at each grade level (preK-grade 1) to adopt the supplemental program as part of their language arts curriculum for the following year (N = 36 teachers). The sample characteristics, shown in Table 1, indicate that the majority of teachers identified as Hispanic and African-American, with other ethnic groups also represented. There was a bi-modal distribution in the years of teaching with a sizable number of teachers having less than 5 years of experience as well as those with 16–20 years in teaching.

Measures

Before our work in schools began, research assistants asked teachers to complete two surveys to better understand their sense of efficacy regarding their background and experiences with science education, as well as their day-to-day pedagogical practices in language and literacy.

The Science Teaching Efficacy and Belief Measure (Riggs & Enochs, 1990)

To gain a better understanding of teachers' previous experiences in teaching science with young children, we administered a brief science survey. Originally designed for later grades, this measure was adapted to examine teachers' confidence in teaching science in early childhood classrooms. Items assessed teacher's background in science, their professional development experiences in science education; their confidence and ability to ask and answer children's questions in science-related topics using a 4-point likert-type scale that ranged from strongly disagree to strongly agree. The adapted survey included 15-items. Cronbach's alpha = .76.

Table 1. Demographic characteristics of teachers in initial implementation (*N* = 36).

Characteristic	Percent
Race/ethnicity	
White	13%
Black	20%
Hispanic	53%
West Indian/Caribbean	6%
Mixed ethnicity	8%
Primary Language	
English	70%
Spanish	17%
Other	13%
Age	
Between 25–34	28%
35–54	59%
Over 55	13%
Years in teaching	
Less than 5	26%
6–10 years	16%
11–15 years	13%
16–20 years	29%
Over 20 years	16%

Survey of Literacy Practices (Hellman, 2017)

Designed to measure common practices in literacy, this measure was adapted from a larger evaluation to focus on related pedagogical instructional practices in our intervention. Teachers were asked to assess the frequency of their informational and narrative reading aloud activities, how often they asked literal and inferential questions, and how often they encouraged children to connect ideas from the text to other topics. In addition, items tapped the frequency of vocabulary activities and opportunities to build multiple meanings of words through their language and literacy block and other activities throughout the day. Teachers recorded these responses using a 5- point likert-type scale, ranging from never to several times a day. The adapted version of the survey included 14 items. Cronbach's alpha = .82.

Treatment Fidelity

Following the implementation of the first three-week topic, two trained research assistants conducted a fidelity checklist in each classroom. The checklist included items related to the components of the lesson and its implementation. Items that addressed teachers' adherence to each component of the lesson included: vocabulary introduction, words connected to the concepts, use of picture cards; shared book-reading and post discussion (5 items). Items that related to the implementation of the lesson included: lesson preparation (e.g., materials organized for lesson), pacing (e.g., within the 12 to 15-minute parameter in the teachers' guide); discussion of topic words; opportunities for children to speak/respond and responsiveness to comments/questions (5 items). Teachers received 1 point for each component implemented, and conversely, 0 points if the component was not implemented, for a possible 10 points. Points were tallied and a percentage was derived to indicate the degree of fidelity for each teacher. Reliability was established between research assistants who independently scored the fidelity checklist. Individual discrepancies were identified and resolved through discussion. These clarifications were made in a follow-up training session.

Lessons were also audiotaped at the same time; 10% of the audios were reviewed by an independent research assistant to ensure adherence to the lesson components. Listening to the audiotaped lesson and using the lesson plan as a guide, the research assistant independently completed the fidelity checklist, and then compared it to the one completed by the research assistants who had observed the lesson in the field. Reliability for the first five items (e.g., adherence to lesson components) was 100%. Reliability for the second five items (e.g., the implementation) was somewhat less precise (80%), although within acceptable boundaries (Stemler, 2004). Once reliability was established, subsequent fidelity checks were conducted by individual research assistants.

Treatment Integrity

At the same time, it was also important to examine treatment integrity, the degree to which the program was implemented as designed and intended. This information could also measure whether additional modifications were needed, either to the program itself or to the teacher supports. With teacher permission, we audio-taped and transcribed three lessons in succession (e.g., 15 min or less).

Procedure

Prior to the start of the study, teachers participated in a one-day workshop. It was designed to introduce them to the curriculum materials and to the program goals. The workshop activities included a description of the instructional design, and the pedagogical strategies used throughout the program (e.g., call and response techniques; asking open-ended, higher-level questions). The workshop also included video examples of expert teachers demonstrating each part of the lesson.

Once a week, for the first 3-week topic, research assistants observed and modeled or demonstrate techniques in the teachers' guides. They also addressed any questions regarding the implementation of the program. Starting with the third topic, observation using the fidelity checklist was conducted.

At the same time, three audio-taped lessons were recorded and transcribed by an independent contractor, serving as another check on treatment fidelity and integrity. Here, we coded the lessons for the percentage of scripted questions and explanations in the teachers' materials. Since these questions and explanations were designed to reflect a "gradual release of control," drawing on Sigel's distancing typology (Sigel, 1985), we coded questions and comments in three categories: low-level distancing (e.g., labeling a picture; chiming a response); medium-level (e.g., comparing/contrasting two or more objects/events); high-level (e.g., proposing a new response). (See Table 2 for examples of coding).

Two trained research assistants independently coded 20% of the transcripts. To calculate the percent agreement, we took the total number of times in which the two raters agreed on whether the comments and questions were placed in the same category (e.g., low, middle, or high), then divided by the total number of comments and questions. Inter-rater reliability determined on the basis of this coding in categories was 95.2%. Subcategory analysis (e.g., labeling within the low category) was coded through coders' discussion and consensus.

Results of Our Initial Implementation

As shown in Table 3, teachers' self-reported confidence in their ability to teach science-related content was low. Scores ranged from a low of 21, indicating little comfort with science content to a high of 56, indicating greater confidence and knowledge about the topic. On the other hand, this was not the case for teachers' knowledge about early literacy practices. Teachers reportedly engaged in frequent practices that included word recognition, fluency, oral language and vocabulary, and use of academic language. Therefore, teachers appeared to feel less confident in the content of the curriculum than in their uses of literacy practices.

Table 2. Categories and examples of teachers comments and questions.

Type	Definition	Example
Low-level cognitive demand	Makes minimal demands on child. Closely related to specific content in text.	"What color is the apple?" "Can you point to the object?" "Where are the wings on an airplane?"
Medium-level cognitive demand	Requires some abstraction and inferential thinking by describing similarities/differences; categorizing objects and properties.	"How is a pond different form an ocean?" "Is a manatee at type of marine animal?" "How are they alike? How are they different?"
High-level cognitive demand	Requires the child(ren) to engage in a re-representation; reasoning and flexibility in problem solving.	"What would happen if there were no insects for frogs to eat?" "How do planes fly?" "What are the ways that animals help people survive?"

Table 3. Teachers self-reported literacy and science-related practices.

Variable	*N*	Mean	Range
Confidence and knowledge about Science	36	29.65 (SD 12.65)	21–56 (low to high)
Literacy Practices	36		
Knowledge about:			5–10 (low to high)
Word recognition		7.84(S.D. 1.29)	
Reading fluency		7.81(S.D. 1.27)	
Oral language		7.71(S.D.1.21)	
Vocabulary		7.55 (S.D.1.31)	
Academic language		7.87 (S.D. 1.08)	

Table 4. Treatment fidelity and treatment integrity in initial implementation of curriculum.

Treatment fidelity	Percent
Variable	
Content coverage (% of components of lessons enacted)	92%
Quality of implementation (e.g., preparation, pacing; facilitating discussion; responsiveness to students)	77%
Treatment integrity	
(e.g., Number of instances over a 60-minute period)	
Number of comments/questions to Students	
Lower-cognitive demand	
Labeling	6.87 (SD 3.75)
Defining	2.46 (SD 1.82)
Telling	7.07 (SD 5.21)
Chiming	10.46 (SD 6.22)
Medium-cognitive demand	
Describing similarities/ Differences	5.94 (SD 4.14)
Categorizing	4.84 (SD 3.61)
Higher-level cognitive demand	
Generalizing	2.33 (SD 1.97)
Inferring cause/effect	1.26 (SD 1.23)
Developing conclusions	1.66 (SD 1.67)

Table 4 describes the fidelity of implementation. Based on the treatment fidelity checklist, teachers seemed to adhere closely to the components of the lessons. They introduced the vocabulary, linked the words and concepts, read the book, used the picture cards, and involved children in post-reading discussion and reflection. At the same time, the ratings were less sanguine about its implementation. According to observer ratings, teachers sometimes seemed unprepared, were hesitant to pick up the pacing of the lesson, and often limited children's opportunities to respond or ask questions about the topic or the book. In short, although the elements of a lesson were enacted as prescribed, the quality of that enactment was less than desirable.

An analysis of teachers' comments and questions further indicated a disjuncture between the prescribed and the intended enactment. Talk related to management issues, or interruptions were not counted. As shown in the Table, over 41% of teachers' talk was low-level: when questioned, children were asked to label or mimic/chime responses. Mid-level responses, encouraging children to compare or contrast and categorize were far less at 18%. Even less often, 6% was devoted to higher-order questioning such as generalizing, inferring cause/effect or developing conclusions. Despite the explicit guidance provided in the teachers' manual to build knowledge networks of concepts and big ideas, teachers' questioning and commenting remained strikingly low-level.

Sources of Variation: Knowledge and Practice

The results of our initial implementation showed that the curriculum alone was insufficient to enhance content-rich instruction. Consequently, we turned to our primary source of variation: teachers' background knowledge. Based on the survey data, it was evident that there was considerable variation in teachers' domain-specific knowledge and use of pedagogical practices in vocabulary and higher-level questions.

Since our conjecture was that teachers need to concurrently draw on both domain-specific knowledge and pedagogical know-how, we used the surveys to purposively select four cases. Contrasting cases of science knowledge with frequency of pedagogical strategies, we identified cases in which teachers were at the highest quartile in both areas; high in one area or the other (e.g., either highest quartile in science knowledge or literacy pedagogy); or low (e.g., lowest quartile in both areas). From these cases, we selected the teachers who had a substantial number of years in teaching overall, as well as within their designated grade to account for teaching experience. In instances where more than one teacher met these criteria, we

Table 5. Focal teacher demographic information.

	Confidence in teaching science+	Use of pedagogical strategies+	Grade	Ethnicity	Language	Highest Degree	Years Teaching
Teacher A	High	High	Pre-K	Latina	Spanish & English	Masters	11–15 years
Teacher B	High	Low	1st	African American	English	Masters	11–15 years
Teacher C	Low	High	Pre-K	White	English	Masters	11–15 years
Teacher D	Low	Low	K	Latina	English & Spanish	Masters	16–20 years

+ Both measures are self-reported

selected a teacher at random. All four teachers were female, with Masters' Degree and 10 or more years of teaching experience. Two identified as Latina, one African-American-and one White. See Table 5 for demographic information.

Our goal was to examine how variations in content knowledge and pedagogy might relate to the quality of implementation. Specifically, we asked:

- How might teachers' content knowledge affect the implementation of a lesson and their uses of pedagogical strategies to promote higher-order thinking?
- Is content knowledge sufficient? Or might teachers need both content and pedagogy to enact a lesson with treatment integrity?

Reviewing a Topic Lesson

For purposes of analysis, we focus on the topic of "Insects" to examine differences in teacher enactment. Like others, lessons in this topic are designed to progress from explicit responses to build knowledge to more open-ended inferential responses. For example, children in this topic are to learn about the names of common insects (e.g., bee; ladybug), recognize common features that form an emerging concept (e.g., all insects have six legs and three body parts), and connect to big ideas that reflect other living things (e.g., insects have habitats based on their needs, life cycles, and strategies to protect themselves).

Using the coded transcripts, Figure 1 describes the number and type of comments and questions for each of the four teachers. Looking across the landscape of teachers' comments at the initial stages of the lesson, one can see a good deal of consistency across cases: All four teachers use low-level questions/comments in the first lessons. For example, following the shared book reading, the teachers' guide recommends engaging children in a "call and response" technique:

Teacher's Guide

Teacher: (Say), ***Just like flies and ants, bees are small creatures that have three body segments and six legs. What do we call these small creatures?*** [Cue children.]
Children: (suggested response) Insects
Teacher: (say) ***Do most insects live inside with people or live outside?*** [Cue children.]
Children: (response) Outside
Teacher: (say) ***How many legs do insects have?*** [Cue children.]
Children: (response) Six
Teacher: (say) ***How many body parts or segments do insect have?*** [Cue children.]
Children: Three

Ms. A, confident in both teaching science and pedagogy, engages in a fair number of conversational turns that are low-level, repeating for the most part questions in the instructional guide. Similarly, the other teachers tend to engage in call and response techniques. For example, following the reading:

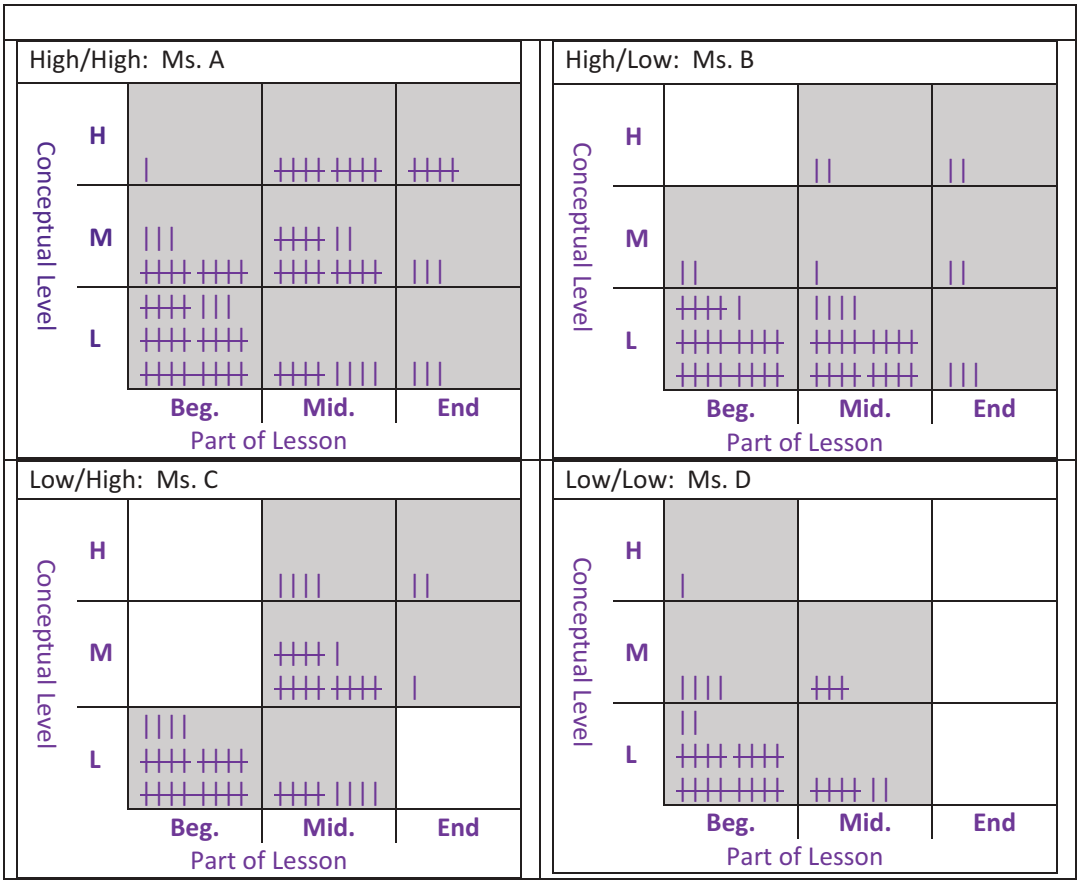

Figure 1. Cross-case comparison of teacher's comments and questions in the beginning, middle, and end of a lesson. Top figures are both high in content knowledge, with different uses of pedagogy (one high, one low). Bottom figures are both low in content knowledge, with different uses of pedagogy (one high, one low). Vertical axis reflects differences in conceptual levels of questioning: low, middle, and high. Horizontal axis reflects different parts of the lesson: beginning, middle, and end. Each mark constitutes a comment or a question.

Ms. C asks children, "What animal did we see in the book?"
[Cue children, "Insect."].
Ms. C: "And what is an insect?"
[cue children, "An animal that has six legs and three body parts."]

Chiming, repeating, labeling were common responses to teachers' questions, a type of check for basic understanding.

Where these transcripts began to diverge, however, is in the follow-up to these initial responses. For example, as shown in Ms. A's case, she begins to ask children more conceptually-demanding questions, such as:

Ms. A: "So we've said that bees and ants are both insects. Then, how are they alike and how are they different?"
Child: "They both live outside."
Child: "They both have six legs."
Child: "Some bees sting, ants don't."

In this case, Ms. A seemed to use the pedagogical strategy of comparing/contrasting to help children begin to build a categorical understanding.

This strategy is in contrast to Ms. B, who reportedly also had a strong background in science. In this case, she follows up the lower-level questions, saying to children:

Ms. B: "So what color is the ground?
Children: [cue "brown"].
Ms. B: "And what color is the ant?"
Children: [cue] "Brown/black."
Ms. B then says, "So why are they brown? What's going on here?"

In this case, it appears to be an effort on her part to build connections across these questions to the big ideas, "that animals need to protect themselves." Nevertheless, the pedagogical technique is too ambiguous to elicit precise responses. Children responded with silence followed by off-topic remarks.

As shown in the Figure, teachers who felt ill-equipped to teach science were more likely to follow the scripted lesson. Both teachers focused primarily on labeling questions in the guide itself, true to the integrity of the program which encouraged teachers to provide frequent repetitions of words and categories. However, their patterns diverged when the curriculum called for more conceptually demanding questions. As the lessons progress, children are encouraged to build knowledge, and categorical understandings first through recall, then through more open-ended responses. For example:

Teacher's Guide

(to Teacher) Show the *Antonio the Ant Becomes an Insect Detective* book and say:
"Let's follow Antonio's adventures and become an insect detective. A detective is someone who follows clues to find out lots of facts. Let's become detectives!"
Teacher: (say) "***Antonio found a buzzing sound. What insect makes that sound?"***
Children: [cue] "A bee."
Teacher: (say) "***Bees live together in a special habitat. What is it?"***
Children: [cue] "A hive."
Teacher: (say) "***Yes, a hive is like a bee's home."***
Teacher: (say) "***What insect is a great hunter?"***
Children: [cue] Praying mantis.
Teacher: (say) "***And what does it eat?"***
Children: [cue] *Other insects.*

True to the intent of the curriculum, Ms. A then moves toward more conceptually demanding questions, using the opportunity to challenge children's understanding. She asks questions like, "Would an ant live in a hive? "Would a praying mantis live among the leaves and trees?" "Why or Why not?" asking individual children in the group for justifications. Following the questions, she then summarizes the discussion, "There are many different habitats, and insects often live in different ones." These questions as well as children's justifications not only required teachers' content knowledge (e.g., to know that katydids live among the leaves looking for food such as a smaller insect called an aphid), but pedagogical knowledge to refine children's responses.

Similarly, Ms. C seems comfortable asking higher-level questions, although she does not feel as confident in science as Ms. A. She asks questions like, "Can you think of some animals that live in different habitats," helping children to connect what they have learned in previous topics (e.g., marine mammals). "What animals would not live in the same habitat as insects?" At other times, she suggests, "Let's think like a scientist. How could we find out more about insects?"

These examples stand in stark contrast to questions and comments of Ms. B and Ms. D, both of whom did not engage children in more challenging talk. In both cases, questions and comments remained at the lower-level despite illustrative examples within the teacher's guide. For example, following the shared book reading Ms. D asks,

Ms. D: "What did we see in the book?"
Child: "a bee"
Child: "an ant"
Ms. D: "Did we see that in the book?"
Child: "Yes"
Child: "No"
Ms. D: "What else did we see in the book?"
Or Ms. B,
Ms. B: "What are some things we see in the forest?"
Child: "A frog."
Child: "A turtle."
Ms B: "A frog, a turtle, what do you see?"
Child: "A fish"
Ms. B: "Are you sure you would see a fish in a forest? Where might a fish live?"
Child: "In shark water."
Ms. B: "In the water … in shark water?"

Here the conversational turns end as Ms. B continues to read. In this example, the teacher neither clarifies nor corrects the child's misconception or attempts to re-direct the discussion back to the habitats of insects. It seems to wander in a new direction entirely. In both examples, teachers seemed to lack pedagogical strategies for engaging children in discussions that could lead to deeper learning.

Toward the end of the topic lesson, teachers are encouraged to help children consolidate what they have learned to support big ideas and to build bridges to other topics. For example, the teachers' manual suggests:

Teacher's Manual

Teacher: ***Good scientists keep making observations, asking questions, and reflecting on what they have discovered. What have we already discovered about insects?***

Suggested responses from children include some of the attributes of insects (e.g., that it has six legs and three body parts), recalling some of the lower-level cognitive demand features. Once these are described, however, how-, what- and why- questions are encouraged, focusing on larger conceptual grouping of habitats, life cycles, and the ways these animals might protect themselves in comparison to others. Finally, the topic lesson ends with "time for a challenge," with the teacher asking, "I'm going to hold up a picture, and let's talk about it, and you tell me whether it is or is not an insect and why?"

As shown in the Figure, none of the teachers spent much time engaging children in consolidating information about the topic. There was limited questioning/commenting at the end of the lesson across teachers. In fact, Ms. D essentially read the entire book straight through without comment before, during or after the reading. Others attempted to make linkages to other topics, with Ms. A ending, "So we've learned about the basic needs of insects. They need food, water, air and protection to survive." "Do you need these things too? Why or Why not?"

Taken together, these cases suggest that although the curriculum materials may support instructional practices, they cannot supplant the need for teachers' knowledge of content and pedagogy. Even the most explicit curriculum may not be comprehensive enough to react to children's queries or comments. As a static document, a guide cannot help teachers adjust or anticipate children's responses or misconceptions, or determine the most apt moments for the "gradual release of control." For this to happen, it will need well-informed and mindful teachers, who may take an ambitious curriculum and use it with the integrity that may best support children's learning.

Discussion

Numerous trials have demonstrated the importance of content-rich instruction, especially for young children who come from low-income circumstances as well as from homes in which English is a second language (Cervetti et al., 2012; Neuman & Kaefer, 2018; Wright & Gotwals, 2017). Instruction that supports such intentional opportunities helps to deepen children's lexical networks of knowledge and vocabulary, skills that are essential for academic learning and text comprehension (Pollard-Durodola et al., 2016). These cognitive processes are framed through high-quality content curriculum and shaped by instructional interactions between teachers and children.

Scaling-up successful content-rich programs, however, has been challenging since the enactment of these curricula materials can vary considerably (Bryk et al., 2015; Cohen & Mehta, 2017). Some teachers may teach strictly by-the-book, adhering closely to the "script" of a teacher's guide while other may exercise considerable flexibility. Sometime the program may be implemented exactly as tested (e.g., do what the guide says to do), demonstrating treatment fidelity and less to treatment integrity (e.g., do what matters most and works best for your children). Consequently, although curriculum materials can enhance the opportunity to provide more ambitious teaching to young children, they are not a panacea. Day-to-day instruction cannot account for the wonderfully unscripted moments of teaching, of listening and responding to children's thinking, their misconceptions, and how they may see their world.

Therefore, although curriculum materials are one of the more powerful influences on children's learning (Chingos & Whitehurst, 2012), they have their limitations. Despite pedagogical guidance, the oft-cited maxim that "people tend to stick to what they know" may be somewhat at play in the enactment of curriculum. For example, in contrast to the recommendations to use more cognitively challenging questions, teachers in our study rarely engaged children in cognitively challenging talk on vocabulary, concepts, or big ideas. Teachers' questions and comments remained strikingly low-level, dominating their conversational interactions with children at 63% compared to only 12% geared toward helping them generalize beyond the text. Unfortunately, such results have been reported in previous studies as well. In examining the prevalence of teachers' discourse to support students' vocabulary in third grade, for example, Carlisle and her team (Carlisle et al., 2013) found that teachers overwhelmingly used shallower discourse actions (e.g., 85% of the total discourse) than those of higher cognitive demand. Similarly, Hollo and Wehby (2017), in a study comparing whole-class instruction in 14 general education and 14 self-contained special education classrooms found that 74% of teachers' utterances were vague and low-level. In our case, fidelity to implementation did not lead to the intended enactment, calling into question whether it is an appropriate conceptual organizer for scaling-up interventions. Rather, as Bryk and colleagues have argued (Bryk et al., 2015), it suggests that a much more complex set of shifts might need to occur to ensure implementation with integrity.

We have proposed that one of those important shifts to achieve higher quality implementation is dependent on building knowledge and skill among practitioners. Examining four contrasting cases, we reviewed the quality of teachers' questioning in classrooms with different degrees of confidence and dispositions toward the curriculum materials and instruction. The teacher with both high content and pedagogical knowledge seemed to ask more higher-level questions; the teacher with less knowledge seemed to struggle and continue to ask lower-level questions. For those with one or the other, the relationship was more complex than straightforward. Although we view these findings as highly speculative, it suggests that content knowledge as a prerequisite for learning might be important for teachers as well as students.

Nevertheless, even after The Nation at Risk report (United States. National Commission on Excellence in Education, 1983), the widely discussed critique of teacher education programs, teacher preparation continues to heavily weigh learning about "educational methods" over learning about content or domain-specific courses (Mirel, 2011). Responding to this challenge, Shulman attempted to build a bridge between content and pedagogy, coining the term pedagogical content knowledge

(PCK) (Shulman, 1987). In his classic work, for example, Shulman argued that teachers needed to be more than just knowledgeable about their subject matter; rather, they needed to represent or transform their subject matter expertise in ways to make it more accessible to students, blending both content and pedagogy. Similarly, more recent work has focused on specific teacher practices, such as *wait time* or discussion techniques that teacher novices can apply in different content areas to support children's learning (Lemov, 2015).

Both approaches, however, *assume* teachers' content knowledge rather than work to build it, using content knowledge almost as a backdrop to focus more intentionally on pedagogical practices. Nevertheless, as Ball and Forzani (2011) have argued, teaching must always be about teaching *something* (p. 38). Consequently, it raises a critical question: how can we better prepare teachers already in the field to know and to be able to use content knowledge more effectively in their practice?

Although there are no easy answers, there are some promising practices. Davis and her colleagues (Davis et al., 2017), for example, have had some success in developing more in-depth educative curriculum to support teachers' learning of subject matter in teaching science content more effectively. Similarly, we have found that providing teachers with background knowledge on science topics appeared0 … … to support more engaging shared book reading discussions as evidenced by the number of conversational turns (Neuman, Samudra & Danielson, submitted for publication). In addition, studies have shown that educational media can anchor instruction in problem-solving environments that both teachers and children can use to explore in deeper learning (Cognition and Technology Group at Vanderbilt, 1990).

We recognize that there are limitations in our research. For example, the selection of the teachers to participate in our project was determined by the principal and might have resulted in selection bias. Other than grade level, we did not establish the criteria for their selection. We also recognize that our knowledge of teachers' literacy practices and confidence in teaching science relied on self-reports, and might not represent their actual practice. At the same time, such self-reports do provide an important indicator of teachers' sense of efficacy in their teaching (Camburn & Barnes, 2004). In addition, we understand that our findings are speculative, and that further research is needed to explore whether these claims can be substantiated.

In summary, we recognize that the implementation of content-rich curriculum surely requires more than teachers' subject matter knowledge and pedagogical supports. To facilitate learning in the early years, teachers must be sensitive to children's development, to the ways in which young children engage in activity, and to understand their personal histories and cultural backgrounds in order to bring these materials to life and to make learning more meaningful. At the same time, we believe that we have underestimated the contribution of teachers' content knowledge, and how it may affect instruction. Too often, professional development has emphasized dialogic techniques (Valdez-Menchaca & Whitehurst, 1992) or ways to support higher-level questioning (Hollo & Wehby, 2017) to the exclusion of the content and subsequent knowledge outcomes that these techniques are designed to promote for children. Although additional research is clearly needed, there is evidence that teachers' content knowledge may support their confidence and skill in teaching content-rich curriculum. It suggests that it may be time to reconsider the equation between content and practice, recognizing that teachers need to master both the content they will teach **and** the best ways to teach it. Like love and marriage as Frank Sinatra would say, "you can't have one without the other."

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References

Allington, R., & Woodside-Jiron, H. (1999). The politics of literacy teaching: How "research" shaped education policy. *Educational Researcher*, *28*(8), 4–13. https://doi.org/10.3102/0013189x028008004

Ball, D., & Cohen, D. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional development. In G. Sykes & L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). Jossey-Bass.

Ball, D. L., & Forzani, F. (2011). Building a common core for learning to teach. *American Educator, Summer*, *35*(2), 38–39. EJ931211.

Bowne, J., Yoshikawa, H., & Snow, C. (2016). Experimental impacts of a teacher professional development program in early childhood on explicit vocabulary instruction across the curriculum. *Early Childhood Research Quarterly*, *34*, 27–39. https://doi.org/10.1016/j.ecresq.2015.08.002

Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000). *How people learn*. National Academy Press.

Bryk, A. (2016, March 17). *Fidelity of implementation: Is it the right concept?* Carnegie Commons Blog, Carnegie Foundation for the Advancement of Teaching.

Bryk, A., Gomez, L., Grunow, A., & LeMahieu, P. (2015). *Learning to improve: How America's schools can get better at getting better*. Harvard Education Press.

Camburn, E., & Barnes, C. A. (2004). Assessing the validity of a language arts instruction log through triangulation. *The Elementary School Journal*, *105*(1), 49–73. https://doi.org/10.1086/428802

Carlisle, J., Kelcey, B., & Berebitsky, D. (2013). Teachers' support of students' vocabulary learning during literacy instruction in high poverty elementary schools. *American Educational Research Journal*, *50*(6), 1360–1391. https://doi.org/10.3102/0002831213492844

Cervetti, G., Barber, J., Dorph, R., Pearson, P. D., & Goldschmidt, P. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research on Science Teaching*, *49*(5), 631–658. https://doi.org/10.1002/tea.21015

Cervetti, G., Wright, T., & Hwang, H. (2016). Conceptual coherence, comprehension, and vocabulary acquisition: A knowledge effect? *Reading and Writing*, *29*(4), 761–779. https://doi.org/10.1007/s11145-016-9628-x

Chiefs for Change. (2017). *Hiding in plain sight: Leveraging curriculum to improve student learning*.

Chingos, M., & Whitehurst, G. R. (2012). *Choosing blindly: Instructional materials, teacher effectiveness, and the common core*. Brookings Institution.

Cognition and Technology Group at Vanderbilt. (1990). Achored instruction and its relationships to situated cognition. *Educational Researcher*, *19*, 2–10. https://doi.org/10.3102/0013189x019006002

Cohen, D., & Mehta, J. (2017). Why reform sometimes succeeds: Understanding the conditions that produce reforms that last. *American Educational Research Journal*, *54*(4), 644–690. https://doi.org/10.3102/0002831217700078

Davis, E., Palinscar, A., Arias, A., Bismack, A., Marulis, L., & Iwashyna, S. (2014). Designing educative curriculum materials: A theoretically and empirically driven process. *Harvard Educational Review*, *84*(1), 24–52. https://doi.org/10.17763/haer.84.1.g8488u230616264/

Davis, E., Palinscar, A., Smith, P. S., Arias, A., & Kademian, S. (2017). Educative curriculum materials: Uptake, impact and implications for research and design. *Educational Researcher*, *46*(6), 293–304. https://doi.org/10.3102/0013189X17727502

Duncan, G., & Murnane, R. (Eds.). (2011). *Whither opportunity?* Russell Sage Foundation.

Dwyer, J., Kelcey, B., Berebitsky, D., & Carlisle, J. (2016). A study of teacher discourse moves that support text-based discussions. *The Elementary School Journal*, *117*(2), 285–309. https://doi.org/101086/688896

Foorman, B., Beyler, N., Borradaile, K., Coyne, M., Denton, C., Dimono, J., … Wissel, S. (2016). *Foundational skills to support reading for understanding in kindergarten through 3rd grade*. Institute of Education Sciences.

Gonzalez, J., Pollard-Durodola, S., Simmons, D., Taylor, A., Davis, M., Kim, M., & Simmons, L. (2011). Developing low-income preschoolers' social studies and science vocabulary knowledge through content-focused shared book reading. *Journal of Research on Educational Effectiveness*, *4*(1), 25–52. https://doi.org/10.1080/19345747.2010.487927

Hellman, E. (2017). *Survey of literacy practices*. Metis Associates.

Hill, H., & Charalambous, C. (2012). Teacher knowledge, curriculum materials, and quality of instruction. Lessons learned and open issues. *Journal of Curriculum Studies*, *44*(4), 559–576. https://doi.org/10.1080/00220272.2012.716978

Hill, H., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *America Educational Research Journal*, *42*(2), 371–406. https://doi.org/10.3102/00028312042002371

Hollo, A., & Wehby, J. (2017). Teacher talk in general and special eduction elementary classrooms. *The Elementary School Journal*, *117*(4), 616–641. https://doi.org/10.1086/691605

LeMahieu, P. (2011). *What we need in education is more integrity (and less fidelity) of implementation*. Carnegie Commons Blog, Carnegie Foundation for the Advancement of Teaching.

Lemov, D. (2015). *Teach like a champion 2.0: 62 techniques that put students on the path to college*. John Wiley & Sons.

Michener, C., Proctor, C. P., & Silverman, R. (2018). Features of instructional talk predictive of reading comprehension. *Reading and Writing*, *31*(3), 725–756. https://doi.org/10.1007/s11145-017-9807-4

Mirel, J. (2011). Bridging the "widest street in the world": Reflections on the history of teacher education. *American Educator, Summer*, *35*(2), 6–12.

National Governors Association Center for Best Practices and Chief State School Officers. (2010). *Common core state standards*. National Governor's Association.

Neuman, S. B., & Celano, D. (2012). *Giving our children a fighting chance: Poverty, literacy, and the development of information capital*. Teachers College Press.

Neuman, S. B., Copple, C., & Bredekamp, S. (2000). *Learning to read and write: Developmentally appropriate practice*. NAEYC.

Neuman, S. B., & Dwyer, J. (2011). Developing vocabulary and conceptual knowledge for low-income preschoolers: A design experiment. *Journal of Literacy Research*, *43*(2), 103–129. https://doi.org/10.1177/1086296x11403089

Neuman, S. B., & Kaefer, T. (2013). Enhancing the intensity of vocabulary instruction for preschoolers at risk: The effect of group size on word knowledge and conceptual development. *The Elementary School Journal*, *113*(4), 589–608. https://doi.org/10.1086/669937

Neuman, S. B., & Kaefer, T. (2018). Developing low-income children's vocabulary and content knowledge through a shared book reading program. *Contemporary Educational Psychology*, *52*, 15–24. https://doi.org/10.1016/j.cedpsych.2017.12.001

Neuman, S. B., Mayotte, J., Dwyer, J., Koh, S., & Wright, T. (2016). *The World of Words: A vocabulary and conceptual development program for preK-grade 2*. New York University.

Neuman, S. B., Newman, E., & Dwyer, J. (2011). Educational effects of a vocabulary intervention on preschoolers' word knowledge and conceptual development: A cluster randomized trial. *Reading Research Quarterly*, *46*, 249–272. https://doi.org/10.1598/RRQ.46.3.3

Pollard-Durodola, S., Gonzalez, J., Saenz, L., Soares, D., Resendez, N., Kwok, O., Davis, H., & Zhu, L. (2016). The effects of content-related shared book reading on the language development of preschool dual language learners. *Early Childhood Research Quarterly*, *36*, 106–121. https://doi.org/10.1016/j.ecresq.2015.12.004

Price, L., Bradley, B., & Smith, M. (2012). A comparison of preschool teachers' talk during storybook and information book read-alouds. *Early Childhood Research Quarterly*, *27*(3), 426–440. https://doi.org/10.1016/j.ecresq.2012.02.003

Riggs, I., & Enochs, L. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education*, *74*(6), 625–637. https://doi.org/10.1002/sce.3730740605

Saçkes, M., Trundle, K. C., Bell, R. L., & O'Connell, A. A. (2011). The influence of early science experience in kindergarten on children's immediate and later science achievement: Evidence from the early childhood longitudinal study. *Journal of Research in Science Teaching*, *48*(2), 217–235. https://doi.org/10.1002/tea.20395

Schneider, R., & Krajcik, J. (2002). Supporting science teacher learning: The role of educative curriculum materials. *Journal of Science Teacher Education*, *13*(3), 221–245. https://doi.org/10.1023/a:1016569117024

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Education Review*, *57*(1), 1–22. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Sigel, I. (1985). A conceptual analysis of beliefs. In I. Sigel (Ed.), *Parental belief systems* (pp. 345–371). Erlbaum.

Stemler, S. (2004). A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability. *Practical Assessment, Research & Evaluation*, *9*. Retrieved 2012, June 7, from http://PAREonline.net/getvn.asp?v=9&n=4

United States. National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform: A report to the Nation and the Secretary of Education, United States Department of Education*. The Commission.

Valdez-Menchaca, M., & Whitehurst, G. (1992). Accelerating language development through picture book reading: A systematic extension to Mexican day care. *Developmental Psychology*, *28*(6), 1106–1114. https://doi.org/10.1037/0012-1649.28.6.1106

Williams, J., Stafford, K. B., Lauer, K., Hall, K., & Pollini, S. (2009). Embedding reading comprehension training in content-area instruction. *Journal of Educational Psychology*, *101*(1), 1–20. https://doi.org/10.1037/a0013152

Wright, T., & Gotwals, A. (2017). Supporting kindergartners' science talk in the context of an integrated science and disciplinary literacy curriculum. *The Elementary School Journal*, *117*(3), 513–537. https://doi.org/10.1086/690273