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Reading Engagement in Science: Elementary Students' Read-Aloud Experiences

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This study examines student reading engagement with children's science books in elementary classrooms. *Reading engagement in science* is conceived in terms of a Transmission—Transaction continuum. When centered on transmission, science reading entails passive reception of a textually encoded scientific message. By contrast, when science reading is transaction-centered, teachers and students actively engage in the negotiation of scientific meanings that transcend the text itself. Examination of reading engagement relied on a discourse-centered method whose analytical goal was to uncover and better understand meaning-making around textual artifacts. More specifically, it took the form of a discourse analysis across three science read-alouds. While meaning-making in one aloud reading was predominantly centered on transmission, the other two read-alouds were characterized by increasing levels of transaction. Further, adoption of transmissive or transactional strategies was consistent with how teachers perceived reading in the context of science instruction. This study underscores the multiplicity of ways that reading can be conceived by science teachers and approached in elementary classroom settings. It is suggested that a more sophisticated understanding of how to systematically engage young students with science texts can help elementary teachers effectively integrate reading with science instruction, meet literacy requirements of current science education policies, and recognize that science reading transcends passive reception of facts.

Keywords: science reading, elementary science, text discussion, science read-alouds

INTRODUCTION

Science educators have long relied on reading of specialized text as a means to promote student learning of science. Traditionally, science reading activity has entailed silent engagement with expository or information texts written by science experts and characterized by a distant and formal authorial voice (Myers, 1992), an impersonal writing style mostly devoid of tentative language (Latour & Woolgar, 1986; Sutton, 1996; Swales, 1995), and high levels of lexical density (Halliday & Martin, 1993). Readers have to work hard to unpack textually encoded information from a lexically dense type of writing that is often perceived as too difficult, dry and uninteresting. Reading engagement with factual expositions has served as the traditional means whereby students are provided with accepted scientific facts organized into a coherent body of knowledge. Such practices are reflective of

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transmissive models of reading (Schraw & Brunning, 1999; Sadoski & Paivio, 2007) centered on student adoption of an efferent reader stance (Rosenblatt, 1978) – a focus on the identification and extraction of text-encoded meanings – and passive reception of conceptual messages that are transferred from the text to memory through unproblematic decoding.

Nonetheless, there is growing realization that reading extends beyond unreflective decoding of the printed scientific word. Scholars like Freire and Macedo (1987) argue that "reading does not consist merely of decoding the written word or language; rather, it is preceded by and intertwined with knowledge of the world… reading the word implies continuously reading the world." Likewise, practitioners have increasingly favored approaches to reading centered on discussion such as literature circles (Miller et al., 2007), book clubs (Alvermann et al., 1999), reading apprenticeship (Creech & Hale, 2006), reciprocal teaching (Palincsar & Brown, 1984), Questioning the Author (Beck & McKeown, 2006), and Text Talk (Beck & McKeown, 2007). With an emphasis on reading texts for discussion (Lawrence & Snow, 2010), these approaches are flexible, dynamic, above the word level, and centered on the co-construction of knowledge and understanding through dialogue; a trend known as the "dialogic turn in reading" (Wilkinson & Son, 2010). For these educators, reading entails active construction of meanings, interpretation, and transaction -- dialogic negotiation and interaction between readers and texts. Evident in this literature is the variety of ways that reading activity can be approached in in classroom settings.

Evidence exists that reading practices can vary widely depending on teachers' implicit mental models of reading (Schraw & Burning, 1999), that is, their largely tacit beliefs about reading (e.g., how they view the role of a reader, purposes of reading, etc.). These implicit beliefs provide teachers with a mental framework that guides their adoption of particular strategies when reading and can shape reading engagement (i.e., how students experience acts of reading). Yet, little attention has been paid specifically to science teachers' implicit models of reading and their potential effects on students' reading engagement with science texts. The present study addresses this issue by means of a systematic and in-depth exploration of science read-alouds at the elementary-school level. More specifically, it seeks to answer the following research questions: (1) What are elementary teachers' beliefs about reading in science? (2) How do teacher beliefs shape student reading engagement with children's science books? The literature that informs this study is reviewed next.

Reading science texts

Though the field of science education has witnessed limited theorizing about reading in general, various aspects of student reading of science texts have been empirically examined. Studies of reading engagement with informational texts have revealed that student comprehension of factual exposition is often made difficult due to the predominance of a complex discursive style characterized by high semantic density or degree of meaning condensation (high number of content words per sentence) and low semantic gravity or degree of meaning dependence on context (predominance of context-independent generalizations) (Maton, 2013; Macnaught, Maton, Martin, & Matruglio, 2013). Decoding and interpreting such complicated texts usually requires downward semantic shifts (re-articulation into less abstract and more contextualized meanings) through pedagogical scaffolds such as literature circles, collaborative concept mapping and other classroom activities involving transmediation (Short, 2004), that is, transfer of meanings across representational systems.

Reading engagement with factual texts is also often complicated by the presence of illustrations that are unclear and difficult to interpret. Images in science texts have been shown to often pose interpretive challenges to readers due to inconsistent structural relations between captions and texts (Pozzer & Roth, 2003; Pozzer-Ardenghi, & Roth, 2005) or poor visual design texts (Ametller & Pinto, 2002; Catley, Novick, & Shade, 2010; Colin, Chauvet, & Viennot 2002; Oliveira et al., 2013; Stylianidou, Ormerod, & Ogborn, 2002). Such findings are in close alignment with the dual-coding theory of reading (Sadoski & Paivio, 2004) which posits that text decoding and comprehension extends beyond the verbal code as readers also process visually encoded messages when engaged in the interpretation of written texts. However, the possibility of student reading and comprehension also being affected by more liminal types of science imagery (e.g., book cover design) remains unexplored, a limitation addressed by the present study.

Aloud reading of science texts is recurrently identified as an effective strategy that teachers can use to shape student reading engagement with science texts. By interspersing oral teacher delivery with whole-class discussions wherein students have the opportunity to construct various types of intertextual links (sense-making connections) to other written texts (e.g., other science books) and metaphorical texts (media, previous discussions, hands-on explorations, previous events) (Pappas et al., 2003; 2004), students are afforded a more dialogic type of reading engagement with science texts. Rather than passively receiving scientific facts from a text, students actively construct meaning through collaborative juxtaposition of texts.

Another strategy previously used to shape students science reading engagement is role-playing. Drama activities have been previously highlighted as an effective means to promote student comprehension of factual texts about complex and abstract science concepts as varied as chemical formulas (Aubusson & Fogwill, 2006), ecosystems (Bailey, 1998), states of matter (Varelas et al., 2010), and wavelengths (Dorion, 2009). These studies emphasize that science texts can be theatrically enacted and reading accomplished through role-playing, a type of instructional activity wherein relations of meanings are collaboratively created between a passage from a science book and body movement based on the referential contents in such passage. This instructional approach is consistent with translational models of reading (Straw, 1990) wherein the reader "translates" pre-existing meanings that reside inside the text itself into a coherent representation while preserving the integrity of its contents.

The above literature shows how student reading engagement can be strategically shaped by science teachers to extend beyond silent and impersonal decoding of written texts. Instead, when carefully designed by science teachers, reading activity can take varied pedagogical formats (silent, dialogic, theatrical) and comprise multiple modes of meaning (transmission, transaction, intertextuality, translation). As such, reading has the potential to provide students with rich and engaging science learning experiences. This study's theoretical perspective on reading engagement is articulated next.

Reading engagement as transtextuality

In this study, science reading engagement is conceived in terms of transtextuality (Genette, 1992; 1997a; 1997b), a theory of reading centered on the premise that the meaning of a text is not located inside the text itself (i.e., intratextually), but in its relation to several other contextual elements that transcend the text, including its material boundaries (title, cover, etc.), other written texts, and oral commentary about the text. From this theoretical perspective, the significance of a text stems from its transtextuality (transcendental relations of meaning with other texts and

external elements) and interpretation is inherently intertextual in nature. Meaning is actively produced by readers (rather than passively received) through the articulation of a particular network of intertextual relations. Based on this theoretical work, a theoretical framework for systematically examining student reading engagement during science read-alouds was developed (Figure 1). This framework identifies five different modes of meaning-making that are available for teachers and students when discussing science texts: intertextuality, paratextuality, metatextuality, hypertextuality, and architextuality (Graham, 2000; Orr, 2003).

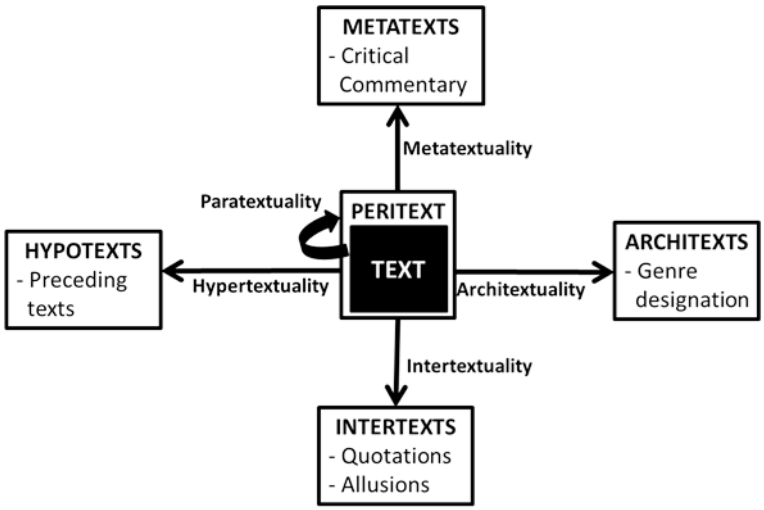


Figure 1. Reading engagement as transtextuality

Each meaning-making mode deals with a particular aspect of the significance of a text under deliberation. Intertextuality is concerned with the significance of a science text in relation to other texts such as previously read books. Paratextuality deals with relations of meanings between a text and its peritext, that is, the material boundaries that separate the text from the immediate context (e.g., the visual design of its cover, title, and subtitle). In addition to providing a text with a threshold or periphery, paratextual elements also serve interpretive functions such as helping readers identify the type text at hand, instructing readers on how to read the text, and conveying author's intentions. Metatextuality is a type of meaning relation that entails critical evaluation a text. Hypertextuality refers to a type of meaning relation between a newer text (called a hypertext) and a preceding text on which the newer text is based (hypotext). Produced by means of transformation, modification, adaption or extension of a hypotext, hypertexts acquire significance by means of juxtaposition to previous texts which led to its production. Lastly, architextuality centers on the designation of the stylistic features of a text as a member of a particular literary genre (e.g., factual exposition and narrative fiction). Occurrence of these different modes of meaning-making during science read-alouds is taken as evidence of varied types of reading engagement.

METHODOLOGY

The present study has a qualitative design (Bogdan & Biklen, 2003; Creswell, 2003) centered on the use of a technological medium (video) for making a naturalistic record (Lincoln & Guba, 1985) of a particular type of pedagogical activity, namely aloud reading of children's science books. Unlike traditional cognitive research wherein the science learner is conceived simply as a holder of (mis)conceptions who grapples with established facts, research within a naturalistic

paradigm treats science learning as sociocultural process (Moschkovich & Brenner, 2000). Rather than producing quantifiable measures of cognition, the naturalistic researcher qualitatively analyzes the classroom culture for the purpose of theory building by examining how members of the classroom community continuously (re)negotiate meanings. Because the analytical focus is on social interaction rather than mental activity, naturalistic researchers align themselves with ethnographic research traditions derived from the social sciences and deliberately seek to avoid mentalism (Lemke, 1990), that is, a paradigmatic trend more typical of the cognitive sciences where research is characterized by decontextualized examination of mental operations.

Adoption of naturalistic, qualitative approach was reflective of the analytical intent of conducting an in-depth exploration without any form of researcher interference with pre-existing reading practices. This exploration was aimed at better understanding naturally occurring practices rather than imposing a particular model of science reading instruction presumed a priori to be the most effective. Further, selection of read-aloud activity was informed by recent research showing a growing presence of teacher aloud readings of picture books in elementary science (Braun, 2010; Heisey & Kucan, 2010; McCormick & McTigue, 2011).

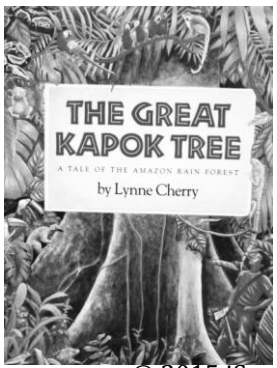
Participants

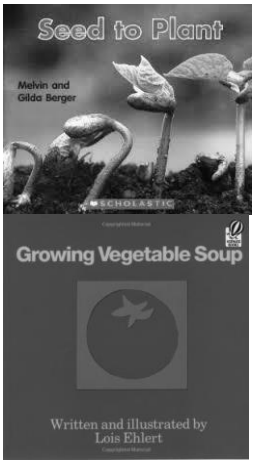
Three elementary teachers, who were assigned pseudonyms, participated in this study: (1) Rosie taught 17 first-grade students in an urban public school and had 22 years of teaching experience; (2) Rachel taught a group of 19 first graders at a private Catholic school and had 15 years of experience; and, (3) Debbie taught a group of 24 second graders at a public magnet school and had 18 years of teaching experience. Drawn from a pool of respondents to a teacher survey of science read-aloud practices, these three participants were selected based on amount of teaching experience, frequency of science reading, and pedagogical strategies. An effort was made to produce a sample of experienced teachers who frequently engaged students in science text reading across a variety of school contexts.

Data collection

The collected data comprised video-recordings of science read-alouds (main data source) supplemented by the teachers' responses to a survey of read-aloud practices (secondary data source). Each classroom was visited once to make video-recordings with a digital camcorder. All video-recordings were transcribed in full and their contents examined in depth to characterize reading engagement with children's science books in each class. The video-recordings captured elementary teachers reading either one or two children's science books of their choice (Table 1).

Table 1. Video-recorded science read-alouds

Book Cover	Science Read-Aloud
	*Teacher*: Rosie *Duration*: 16 minutes *Book Title*: The Great Kapok Tree (Cherry, 1990) *Genre and Stylistic Features*: Fictional storybook that narrates the story of a lumberjack who intends to cut down a large tree in the Amazon rainforest with his ax. Exhausted, the man falls asleep under the tree and is approached by a number of talking animals (a boa constrictor, a bee, a monkey, a toucan, a macaw, a cock-of-the-rock, tree frogs, a jaguar, tree porcupines, anteaters, a sloth) who repeatedly plead with him to spare the tree and point out all the harmful environmental effects that will result from the destruction of the forest. Moved by the animals, the lumberjack ends up leaving the rainforest without cutting the tree. Colorful and large paintings are used to portray in vivid details the tropical fauna and flora.



Teacher: Rachel
Duration: 20 minutes
Book Title: Seed to Plant (Berger & Berger, 2004) and Growing Vegetable Soup (Ehlert, 1987)
Book Genre and Stylistic Features: "Seed to Plant" is a non-fictional picture book that provides an expository description of the biological development of seeds into plants overtime. Illustrated with large and colorful photographs of a variety of seeds and plants (coconuts, peaches, etc.), this book provides descriptive information regarding the physical attributes of seeds (sizes, shapes, etc.), identifies the environmental conditions for seed growth (soil, water, air, and sunshine), and describes the occurrence of seeds inside different plant parts (flowers and fruits). In addition to the main line of text, the author also includes side notes entitled "fun facts," wich provide readers with additional factual information regarding seeds (e.g., "the pits in plums, cherries, and peaches are seeds").

Teacher: Debbie
Duration: 40 minutes
Book Titles: The Mystery of Magnets (Berger, 1996) and What Makes a Magnet? (Branley & Kelley, 1996)
Genre and Stylistic Features: "The Mystery of Magnets" is a very large, non-fictional poster book that provides an expository description of different types of magnets (horseshoe, block, rod, bar, disk, u-shaped) and basic concepts of magnetism (magnetic poles, magnetic fields, attraction to metallic objects). Illustrated with colorful pictures of a diversity of magnets and metallic objects, the book's layout follows a traditional textbook format, with a table of contents and a word index at the end. "What Makes a Magnet?" is a hybrid storybook written in the form of an informational narrative wherein fictional characters (a girl and a mouse) conduct several experiments and hands-on activities using magnets (e.g., fishing with a magnet, making their own magnets) and introduces readers to the compass (its common uses and history) and principles of magnetism (magnetic poles, attraction and repulsion, Earth's magnetism, magnetite, etc.). The book is illustrated with cartoonish drawings that are colorful and frequently include dialogue and thought bubbles.

Another data source was a survey of science read-aloud practices sent to teachers prior to the video-recording. The survey was composed of a series of open-ended questions that asked for demographic information, teacher preparation and experience and pedagogical information: (1) How often do you read science books aloud to your students and for what purpose(s)? (2) What science books have you recently read aloud to your students? (3) Do you and your students have any favorite science books? (4) What makes these books favorites? (5) Are there books that you and your students do not share a preference for? (6) What criteria do you use to select science books for read-alouds? (7) How do you incorporate read-alouds into your science teaching? (8) What teaching strategies do you commonly adopt when reading science books aloud? (9) How do you assess what your students learn from science read-alouds?

Data analysis

Examination of reading engagement relied on a discourse-centered method (Farnell & Graham, 1998) whose analytical goal was to uncover and better understand meaning-making around textual artifacts. More specifically, it took the form of a discourse analysis (Erickson, 1996; Gee & Green 1998), that is, an up-close analytical examination of the discursive resources strategically used by teachers and

students to create meanings around children's science books. With a micro-genetic focus on unfolding short-term processes in face-to-face communication (Wertsch, & Hickman, 1987), this discourse analysis involved attending to spoken language. Further, systematic examination of transcribed recordings was combined with sequential analysis and playback of video-recordings (see appendix for transcription conventions). More specifically, transcripts were first read carefully and up close to identify *key scenes* or *episodes* (Erickson, 1996), that is, short stretches of naturally occurring discursive interactions that captured the main features of reading engagement in each classroom. Video clips and excerpts of each scene were then repeatedly examined, contrasted, and (re)interpreted in light of the theoretical and empirical literature reviewed above. Out of this flexible analytical approach emerged this study's focus on transtextuality (text transcendence).

Drawing upon transtextuality theory (Genette, 1992; 1997a; 1997b) and emergent trends during initial inspection the transcribed video-recordings, an analytical distinction was made between five different types of dialogic reading strategies: paratextual, metatextual, intertextual, architextual, and hypertextual. Rather than imposed, these analytical categories emerged out of alignment between empirical trends in the collected data and theoretical insights from the literature on transtextuality.

Paratextual strategies focused mainly on threshold or material boundaries of a given science text (title, book cover design) rather than the science text itself.

Metatextual strategies were focused on conveying particular evaluative attitudes (Tannen, 1985) toward the science text being read aloud (i.e., verbalization of evaluative messages regarding some particular aspect of the text such as scientific accuracy). Metatextual strategies were characterized by the emergence of a critical stance (Hyland, 2005) toward a science text as speakers deployed evaluative resources mainly to communicate critical opinion, judgment or appraisal (Martin, 2000; White 2003).

Intertextual strategies juxtaposed and connected across multiple texts for the purpose of collaboratively making sense of the science text at hand. A defining feature of intertextual strategies was the explicit interweaving and interblending of texts as evident by the occurrence of "traces of other texts" (Bazerman, 2004) or "snatches of other texts" (Beacco et al., 2002).

Architextual strategies focused mainly on the identification and description of a written science text as belonging to a particular genre (Swales, 1990) -- a particular type, class, or category of literary work such as nonfictional exposition or fictional narrative. These included comments upon the writer's usage or failure to use a particular register (Halliday, 1975), that is, a specialized subset or context-specific variety of language (Saville-Troike, 2003). Meaning-making was devoted to characterizing the stylistic norms of science (Lemke, 1990).

Hypertextual strategies were characterized by the emergence of a performative frame (Bauman, 1977), that is, theatrical performance or enactment (i.e., expressive and artistic rendition of a science text in action terms). Hypertextuality was conceived as a type of interpretive activity centered on dramaturgical meaning-making (teachers and students behaved like performing actors on a stage).

Teachers' reading beliefs were examined through the adoption of a qualitative analytical approach that incorporated elements of grounded theory (Glaser & Strauss, 1967). This approach called for the iterative and combined use of interpretative and flexible methods of analysis such as close reading, inductive or open coding and memoing (Emerson, Fretz & Shaw, 1995; Bernard, 2002). There were no *a priori* hypotheses or codes. Instead, analytical categories emerged and were gradually refined based on close examination of meanings and patterns in the collected survey data. This analytical process led to the identification of teacher

beliefs about reading that were characterized by varied degrees of emphasis on *transmission* of science content and *transaction* (negotiation of science meanings).

Analytical validity was fostered by providing participants with an opportunity to provide insight into their experiences (through their responses to the survey) and by means of data triangulation across observational and self-reported sources of evidence, triangulation in time and space (comparative analysis of reading practices in multiple research sites) and peer debriefing with researchers who shared an interest and expertise in reading instruction (doctoral students and education faculty). Within a naturalist research paradigm, triangulation serves to guard against individual researcher biases (Robson, 2002) and to enhance the study's credibility and trustworthiness (Patton, 2002). Comparing and contrasting across different data sources serves to produce an analytical account that is a credible and trustworthy representation of participants' experiences (as opposed to reliable coding frequencies).

FINDINGS

The above analysis revealed varied types of reading engagement across the science read-alouds. While meaning-making in Rosie's aloud reading was limited to only two modes of meaning that indicated predominance of transmission, Rachel's and Debbie's read-alouds was characterized by larger numbers of modes of meaning that were indicative of increasing levels of transaction-centered engagement. These different types of reading engagement were situated at different locations along a Transmission—Transaction continuum (Figure 2).

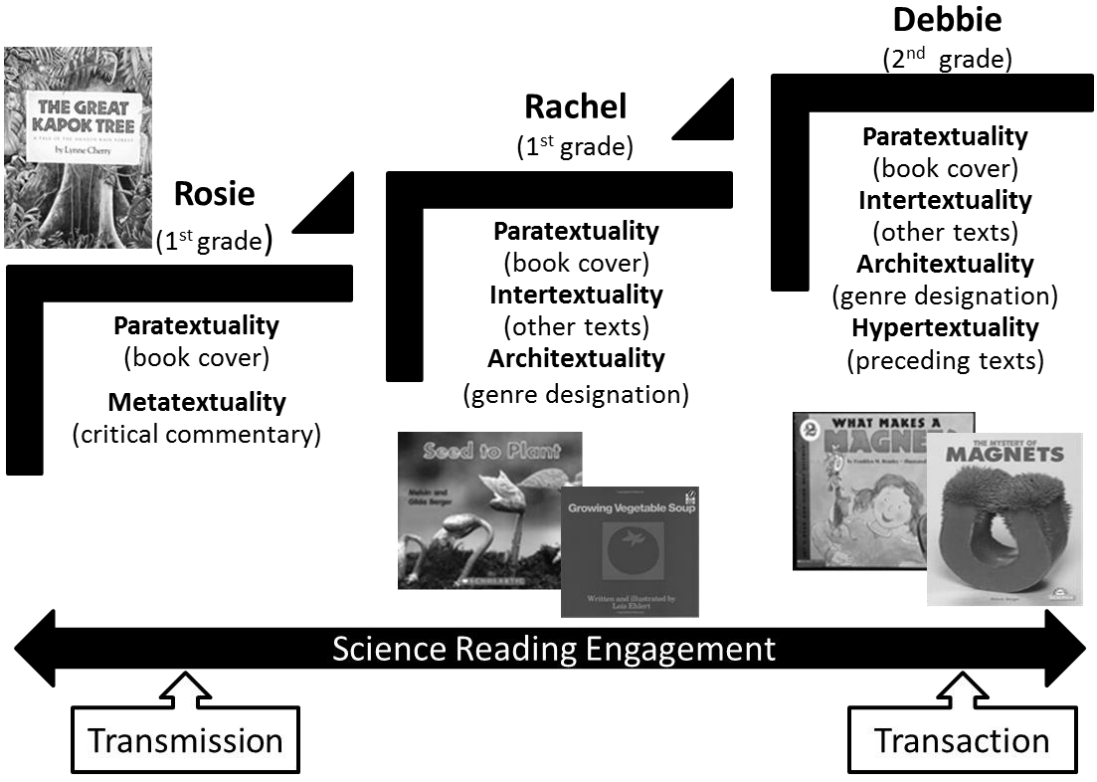
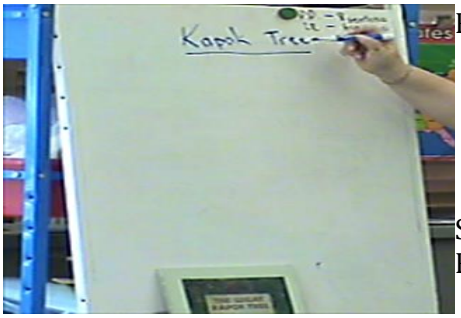


Figure 2. Reading engagement across science read-alouds

Rosie's read-aloud

Emphasis on transmission pervaded the aloud reading of *The Great Kapok Tree* – situated toward the transmission end of the reading engagement continuum (Figure 2). After discussing the cover page, Rosie (first grade) turned attention to a world map showing the locations around the globe where kapok trees can be found, and to a short text entitled author notes, which provided the scientific names and definitions for the different parts of a tree (canopy, story layer, forest floor, and emergent layer) and the types of animals who commonly inhabit each part. Her aloud reading was characterized by verbatim oral text delivery with reduced dialogical interaction with the students, and a wide assortment of gestures and vocal variations (character voices, volume changes, etc.). This monologic type of reading engagement was disrupted near the end when oral delivery when she prompted students to discuss what they thought the character would do – continue to chop down the tree or leave.



Rosie: A KAPOK TREE [writes on the board] is a very large tree that lives in tropical rain forest, it lives in America, Africa, and East Indies… it has flowers, so it's a tree that has flowers, did our maple tree have flowers?
Students: No.
Rosie: It's called The GREAT Kapok Tree, we are going to read this story, it's a tale of the Amazon rainforest, it's by Lynne Cherry, and you can see some animals up in the tree canopy [points to cover]

Students: A lot, I see a person!
Rosie: the understory, and the forest floor [points to cover].
Students: I see my anteater!
Rosie: I am sure you're going to see lots of your animals in here.

Rosie and students' reading engagement with the book cover has a strongly transmissive focus mainly on verbal decoding (defining unfamiliar words such as "kapok tree") and visual decoding (naming rainforest animals). Further, by writing "kapok tree" on the white board, she signals that this is a key word to be recalled. Her practices indicate a strong focus on ensuring transmission of content and a concern with fostering student reception information encoded in the cover design, title and subtitle rather than engaging them in transactional meaning-making.

Metatextuality. Having read the end of the story aloud (the lumberjack's decision to listen to the animals' plea and not cut down the great Kapok tree), Rosie and the students engaged in a short metatextual exchange:

John: He didn't do it, I knew he wouldn't.
Rosie: He did not do it. What do you think? Do you like that choice that he made [thumb up], you're not sure [thumb sideways], or you don't like the choice he made [thumb down]?
Students: Yeah, I like the choice [many thumbs up]
Rosie: Yeah, I think he made the right choice too.

Rosie and the students critically comment upon the main character's chosen course of action. Their critical commentary has a moral character – is focused on the morality of the story. Rather than commenting upon scientific accuracy (e.g., the fact that animals cannot verbally communicate with humans as described in the story), Rosie and the students evaluate whether the narrative's ultimate resolution was morally right ("whether the man made the right choice"). Such a focus indicates that a more transactional type of reading engagement emerges toward the end of the read-aloud.

Rachel's read-aloud

Centrally located along the Transaction-Transmission continuum (Figure 2), reading engagement in Rachel's classroom (first grade) included the two additional meaning modes of intertextuality and architextuality. In addition to prompting students to articulate peritext-text meaning relations, Rachel and the students also articulated text significance in relation to the larger scientific genre and considered meanings across texts. Her reading practices served to ensure student reception of visually and verbally encoded content (scientific information about biological development of edible vegetables) and engaged students in transactional meaning-making. Aloud reading of the book *Seed to Plant* was immediately followed by aloud reading of *Growing Vegetable Soup*.

Rachel: Now, wait a minute, <u>can you grow</u> vegetable soup?
Students: NO!
Rachel: No, that [the book title] <u>sounds ridiculous</u>, doesn't it?
Joe: <u>You can grow</u> vegetables and put them in a soup.
Rachel: You're <u>absolutely right</u>.
Adam: But <u>you can't grow</u> a cup and a spoon.
Rachel: <u>You can't grow</u> a cup and a spoon, <u>can you grow</u> a bowl of hot soup?
Students: NO!
Ann: And <u>you can't grow</u> broth.
Rachel: No, <u>you can't grow</u> broth either.

By critically commenting upon the book title ("that sounds ridiculous," "absolutely right," "you can," "you can't"), Rachel encouraged students to evaluate what the nonliteral expression "Growing Vegetable Soup" (a metonymic and metaphoric phrase wherein the action verb "making" is replaced by the closely associated verb "growing") meant from a scientific perspective. Her concern with

accurate student reception of content (making sure that students understand that soup is not a vegetable and cannot actually be grown) is indicative of a transmissive type of reading engagement.

Intertextuality. Rachel and the students also articulated intertextual relations of meaning between the two books *Seed to Plant* and *Growing Vegetable Soup*. Intertextual meaning-making centered on first predicting (based on the available paratextual clues) and later confirming (based on their reading of textual contents) how the two science texts were interconnected:

Rachel: Today we are going to read two books, and who can guess what they are going to be about? Big guess, let's see, Adam, what do you think?

Adam: Mmm, tomatoes and seeds.

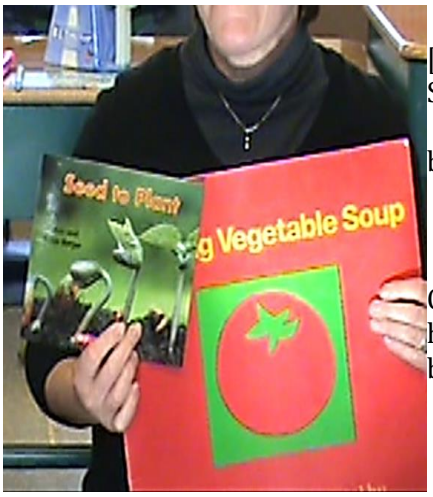
Rachel: You think it's going to be about tomatoes and seeds.

Ann: I think it's gonna be about vegetables.

Rachel and students' attention to the joint significance of the two texts is indicative of transactional meaning-making. Rather than emphasizing accurate transmission of the content of each individual book, reading engagement centers on the construction and negotiation of intertextual meanings through juxtaposition and comparison of the two books. Their discussion leads to the identification of an intertextual link first labeled as "tomatoes and seeds" and then generalized to the larger category of texts about "vegetables."

Central to intertextual transaction was Rachel's line of questioning. As shown above, Rachel posed questions that intertextually linked the peritexts of the two books ("Today we are going to read two books, and who can guess what they are going to be about?") while holding them in physical proximity. In doing so, she encouraged students to construct a relation of meaning across peritexts (as opposed to making sense of each text individually). Their significance was articulated in terms of multiple "text-peritext" meaning relations, an indication of transactional type of reading engagement.

This intertextual transaction also occurred at the end of the read-aloud:



Rachel: Can somebody tell me how this book [Seed to Plant] and this book [Growing Vegetable Soup] were alike? Ok, Ann.

Ann: I think they're both growing, mmm, both were growing and growing.

Rachel: They were both about growing.

Mary: They were both about seeds growing.

Rachel: They were both about a seed growing. Ok, what is that called [makes a circle with right hand in the air]? When we see things from the beginning to the end, what is called?

Sheryl: A, uhh, a cycle?

Rachel: a cycle, what kind of a cycle?

Students: Food cycle? Food chain? A life cycle!

Rachel: Life cycle, the life cycle of a seed, it goes from seed and then grows into a plant.

Having examined the textual contents of each book individually, Rachel and the students now elaborate on the intertextual significance of the two books. As a result, the intertextual link between the two books acquires an increasing level of conceptual specificity (growing → seeds growing → the life cycle of a seed). Rather

than simply relying on surface text features (visible paratextual clues), Rachel and the students seek to identify a single science concept central to both two books (i.e., negotiate what constitutes the "common theme" across the science texts).

Architextuality. In addition to designating each science text as belonging to either a factual or fantasy genre, Rachel also identified their specific stylistic features and gave students explicit instructions on how to read each particular type of text. For instance, while reading *Seeds to Plant*, Rachel repeatedly directed students to "read all of the words":

Rachel: Boys and girls, did I read all of the words on this page?

Students: Yeah, no, no [disagreement].

Joe: Right there [stands up and places finger on a balloon on the side of the page]

Rachel: Right there, what does it say, Joe?

Joe: It says [begins reading aloud] "fun fact: seeds come in many sizes and shapes"

Rachel:You're absolutely right, seeds come in many sizes and shapes, now, boys and girls, that's a caption that I don't want to miss, that's important information I don't want to miss.

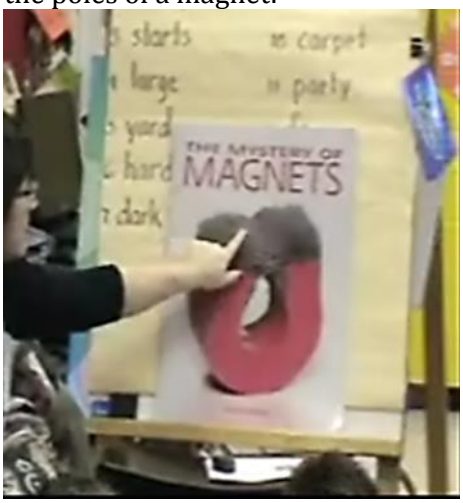
By highlighting the need to read verbatim a science text previously designated as being "about something real" (i.e., nonfiction), a relation of meaning is created between the text and the factual genre to which it supposedly belongs. This emphasis on lexical accuracy and precision when reading factual texts is consistent with the notion *efferent reading* (Rosenblatt, 1978), that is, the adoption of an informational stance aimed primarily at finding a particular meaning (Straits, 2007; Straits & Nichols, 2007; Straits, Zweip & Wilke, 2011). Factual science books are to be read in their entirety for the precise extraction of certain scientific meanings (i.e., absolutely all words should be taken into account). This architextual meaning is indicative of reading engagement centered on transmission (i.e., student reception of textually encoded information). Reading all words is presented as means to ensure that scientific facts are accurately received by readers.

Debbie's read-aloud

Situated toward the transaction end of the reading engagement continuum (Figure 2), Debbie's (second grade) read-aloud encompassed the highest number of meaning modes: paratextuality, intertextuality, architextuality, and hypertextuality. Reading engagement included text enactment or dramatization wherein relations of meaning were constructed between a written narrative (the script) and its adaptation into a roleplaying activity (a metaphorical and multimodal text composed of words, gestures, physical movement, and even props). Rather than detached and outside readers, students positioned themselves as the characters in the narrative (a girl and a mouse), making the narrated actions their own and symbolically inhabiting the text itself by crossing over the boundary that separates the narrated and narrating worlds. The resulting inner perspective enabled them to "read the text from the inside" by experiencing firsthand the narrated events involving magnetism. Aloud reading of the book *The Mystery of Magnets* was immediately followed by aloud reading of *What Makes a Magnet?*

Paratextuality. Like the other two teachers, Debbie started the aloud reading of each science text by engaging students in paratextual exchanges. She guided students' paratextual reading of the books by prompting them to explain visually

represented magnetic phenomena, namely the concentration of iron fillings around the poles of a magnet:



Debbie: Who can tell us what's going on [points to iron fillings at the top of the magnet]?

Joshua: Umm, it's metal shavings.

Debbie: It's iron fillings, but why are they all gathered at one spot?

Mary: Because it has metal in them.

Debbie: Yes, we said that, but why are they gathered here [top of magnet]?

Peter: Because the poles are the strongest of the magnets.

Debbie: It's the strongest area so they all gather up, so it's very weak here [bottom of magnet], but denser here [top of magnet].

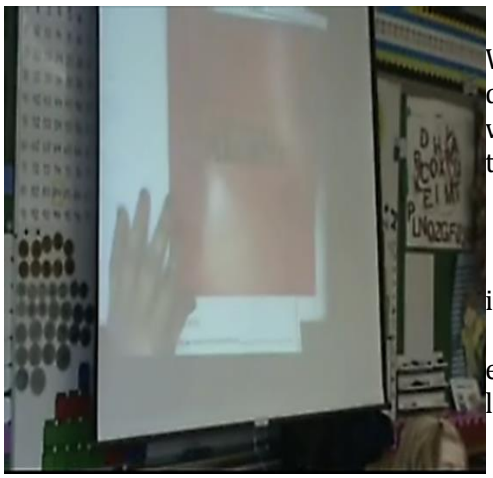
Debbie' interaction with students is centered on transaction, that is, negotiation of meanings surrounding book cover. This is evident in Debbie's adoption of a line of questioning aimed at articulation of a scientific explanation for the book cover design ("why are they [iron fillings] all gathered at one spot?"). Rather than simply receiving scientific information about magnetism, students actively co-construct scientific meanings with regard to the location of magnetic poles and strength of magnetic force as portrayed on the book cover. Central to this transactional engagement is the making of claims supported by visually accessible evidence.

Debbie also directed students to evaluate the cover of *What Makes a Magnet?*:

Debbie: Everybody's eyes on the Elmo [showing cover on overhead projector], and take look at what she is holding, now I see a mouse doing this [hanging from metallic objects stuck t the word "magnet" on the title], now I know that not something that could happen, so I think Franklyn Branley [author], we're gonna learn something, but maybe they're gonna do some fu things in here as well.

Debbie's directive is followed by critical commentary about the book cover (i.e., book cover criticism). The presence of a seemingly fictional element on the book cover (a mouse displaying what appears to be abnormal and unrealistic behavior for mice) is evaluated as an indication that the text is a literary hybrid combining stylistic features of both factual and fictional genres. By prompting students to consider the scientific accuracy of this unexpected paratextual element, Debbie momentarily favors transmission.

Intertextuality. Debbie engaged students in the creation of intertextual links between the two books *The Mystery of Magnets* and *What Makes a Magnet?*:



Debbie: What Makes a Magnet? [reads title aloud] Why is there a question mark there? I didn't see a question mark on that title The Mystery of Magnets, why is there a question? What makes a magnet? The title is what? What makes a magnet?

Mary: Question?

Debbie: Why there is a question?

John: It's like, if you don't know what a magnet is then you do that [ask a question].

Debbie: Well, the title is asking, telling you, you either know what makes a magnet or you're gonna learn.

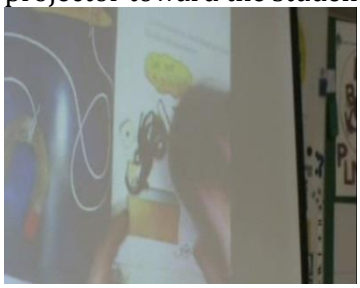
By comparing their titles, Debbie encourages students to reflectively consider alternative formats ("question" versus "telling title") and what each particular format reveals about the nature of their respective science texts. More specifically, it creates the expectation that the science text about to be read is to be understood as an answer to a *display question* (Oliveira, 2010), a closed type of question traditionally used by teachers to test student's recall of factual knowledge ("the right answers").

Architextuality. Debbie also emphasized the importance of precise reading of science texts. While reading the *Mystery of Magnets*, she gave the following directive to her students: "Remember when we read science books, we do not skip labels." Reading scientifically is equated to an interpretive act wherein a text is carefully and systematically read in their lexical entirety (all words). Further, an architextual meaning relation is created between a literary category (the "science books" genre) and particular way of reading ("not skipping labels"), thus constructing science text reading as an efferent type of activity.

Hypertextuality. This meaning was central and unique to Debbie's read-aloud. Reading engagement with *What Makes a Magnet?* centered on transactional meaning-making through theatrical enactment (i.e. role playing). This began with the aloud reading the following passage found at the beginning of the book:

"Let's go fishing. Put different things in a box: a penny, a nickel, and a dime, a twig, some tacks and paper clips, bits of aluminum foil, rubber bands, pieces of paper and a pin or two. Next find a magnet, tie one end of the string around your magnet, tie the other end to a stick or pencil, go fishing in a box. Put the things you catch in a pile, the others will stay in the box."

Debbie suddenly and unexpectedly interrupts her aloud reading of the book, grabs a container with science manipulatives, and walks away from the overhead projector toward the students. The following exchange ensued:



Debbie: So, we're gonna fish [grabs a can with objects].

Students: Oh! Cool! [excitement around the room]

Debbie: We can all sit because, you're all gonna be able to see it. Okay, you will need to know what's in the box before you can decide what's gonna come out, so take a look at [pours out the objects inside the can on overhead projector] at what's inside the container: a plastic button, a thimble, a paper clip, a washer they are called, a plastic little goat, a ball, a cube, and a dice. So, make your decision in your head right now, which items you feel are going to stick to the magnet. I am gonna put them all back into the container, and this magnet should only

pick up the ones that have, well let's see…okay, here we go.

Students: Yeah, cool!

Debbie: Did you think that [fishes paper clip and thimble Is there anything else that it might catch?

Joe: Yeah, the ball.

Debbie: Do you want to fish? You can't look.

Joe: [fishes an object]

Students: Yeah, oh [excitement around the room]

Debbie: So we went fishing, when you go really fishing a you get something they call it a nibble, so we've got four nibbles.

As can be seen above, a preexisting text (a hypotext) is transformed into a theatrical adaptation (a metaphorical hypertext) wherein Debbie and the students take turns playing the book's main character (a little girl) by performing (imitating) her physical actions as described in the hypotext. This form of meaning-making is consistent with the notion of hypertextual translation and Graham's (2000) argument that "the processes of transtextuality involved in hypertextual translation… involve a resignification or a semiotic utilization of a previous formal structure for means other than those produced within the original structure (p. 113)." Likewise, in the above exchange, the science text is hypertextually translated into a hands-on science activity through transposition of some elements (fishing pole made up by a pencil, string and magnet) and modification of others (a can instead of a box, a different set of objects, etc.) into new signifying relationships. Rather than receiving factual information, students take part in a transactional reading engagement wherein they are encouraged to physically experience the actions described in the text for themselves ("inhabit" the world of the science text).

Teacher beliefs about reading

Evident in the survey data was the varied degrees of emphasis placed by the participating teachers on transmission of science content and transaction of meanings (Table 2). When asked about their learning goals, teaching strategies, and assessment practices adopted during science read-alouds, Rosie expressed beliefs about reading centered primarily with ensuring student reception of the factual contents of books read aloud. Driven primarily by content-focused learning goals, she conceived of science reading as a means to foster student conceptual understanding, information recall, and factual accuracy. On the other extreme was Debbie who held reading beliefs centered on student engagement with transaction (meaning- and sense-making). Her main focus was on collaborative interpretation, interaction, creation of meanings, and making connections. Transmission was given only secondary consideration. Lastly, Rachel was more balanced in her attention to both transmission and transaction in science reading. These findings are consistent with the reported observations of reading engagement during science read-alouds. In other words, science read-alouds practices (i.e., location along the Transmission-Transaction continuum) for the most part reflected elementary teachers' beliefs about reading in science. Adoption of transmissive or transactional strategies was consistent with how teachers perceived reading in the context of science instruction.

Table 2. Elementary teachers' beliefs about reading in science.

	Rosie	Rachel	Debbie
Goals	My purpose is <u>to build my students' background base</u>. I also use the New York state standards <u>to identify content</u> that is to be taught in the first grade curriculum… students ought to learn about <u>living organisms and interdependence</u>.	To <u>introduce new topics</u>, you know facts. Books must be <u>topic specific</u>. I want them **to take something home**. There's a recipe in this book for growing vegetable soup and it's extended past school and get them and their families more involved.	To <u>introduce concepts</u>, and <u>reinforce existing ones</u>. **To use the knowledge** they already have, **for them to make connections**. I try to make sure that **they broaden their horizon** and that they <u>assimilate the information</u>, it becomes part of them.
Strategies	I like to ask <u>what they know</u> about a science topic before we read. I select books that are written with <u>easy to understand text</u>. I would like to have <u>a real picture of a Kapok tree</u>… an aerial view. They <u>listen to the text first</u> before a display the picture.	I select books that offer **endless possibilities for discussion** and potential activities also. **Possibilities for writing extensions**. <u>Activate prior knowledge</u>, **cooperation**, discovery, observation. They have to read all of the words because <u>there are important facts</u> They have to **infer what's going on** in the story.	It is <u>not just a straight read</u>, I **have them interpret the information and place into the book**. I also give them a chance to **put things into their own words**. <u>Direct instruction has a place</u>, but the children need to be **interacting with the text**. <u>There is sometimes room for a cold read</u>, but the kids need to be able to **grab on to something**, they need to **tie in their background knowledge**, they need **to make a bridge**.
Assessment	I usually do an informal assessment by thumbs up – yes, I <u>get it</u>, thumb sideways – I <u>kind of understand</u>, and thumb down – I <u>don't get it</u> at all. I can understand from their discussion if <u>they understood the concept</u>… if they are <u>making the right connections</u>.	Using a question/answer format I assess for <u>comprehension of the topic</u>. And lists, I ask them to write a list. [Later] I can say "here's your list, I want you to use these three words that you wrote on your list, and **write me a story, or write me a paragraph** about what plants need to grow." So, it's a beginning.	Questions and answers. I also have students **interactive strategies** with the books…creating webs, t-charts, or KWL. I want them to **create questions** that may be asked in the future.

** <u>Underlining</u> indicates emphasis on content transmission (i.e., teacher-centered communication of factual information to students).*
**** Bold** indicates emphasis on transaction of meanings (i.e., student-centered negotiation of ideas and active co-construction of knowledge).*

DISCUSSION

Reading engagement in science can center on transmission and transaction to different extents. When the center is on transmission, science reading is a pedagogical activity aimed simply at passive reception of a textually encoded scientific message. By contrast, when science reading is transaction-centered, teachers and students actively negotiate the meaning of the scientific word in relation to book covers and titles (paratextual reading), other texts (intertextual reading), genres (architextual reading), and critical commentary (metatextual reading). This finding underscores the multiplicity of ways that science text reading can be approached in classroom settings. Its significance is now discussed in light of the existing scholarly literature.

Paratextual reading

One noticeable trend in the above findings was the recurrence of paratextual reading engagement across the examined science read-alouds. As shown above, science read-alouds were not limited to science texts inside children's books as teachers and students invariably engaged with book covers as well. Transmission-centered paratextual engagement was common to all three read-alouds, being characterized by a shared concern with the scientific accuracy and clarity of visual and verbal elements (e.g., front-cover illustrations of animal behavior, and non-literal expressions and unfamiliar words in the titles). By contrast, transactional engagement with science book cover only occurred during Debbie's science read-aloud where students actively used the book cover as source of visual evidence for their claims and co-constructed scientific meanings with regard to the location of magnetic poles and strength of magnetic force.

This finding is consistent with arguments previously made by scholars who emphasize that books are more than disembodied texts, they are also visual media whose materiality (cover, layout, illustrations, jackets, annotations) are central to the processes of reading and digestion of textual contents. As Mathews and Moody (2007) write, "book covers – the wrapping of image, typography and puff prose that surrounds the written contents of a book really matter… because, as readers, we do indeed judge books by their covers (p. xi)." More than mere decoration, book covers serve as visual conduit for author-reader negotiations to take place with regard to content, genre, and literary value. As such, paratextual illustrations have a potential to influence the aloud reading of science texts in elementary classrooms and can be strategically exploited by teachers to foster transmission as well as transaction.

Teacher-student engagement in paratextual exchanges prior to reading the actual science text is consistent with what research identifies as an effective strategy for successful reading, namely developing students' ability to predict the nature and content of a text based on advanced labels (Tadros, 1994) and metalinguistic signals (Hoey, 1994). As Tadros (1994) writes,

In the area of reading, it is very important to make students aware of signals of Prediction in order to enhance their reading efficiency. They must be trained, for instance, to recognize signals of Advance Labelling so that they look for the fulfillment of the act labeled (p. 81).

Thus, reading paratextual elements can help readers recognize that the writer is committing himself or herself to the performance of a particular type of discursive act (e.g., telling a story, reporting facts on a particular topic) through the provision of a metalinguistic label (the book title) and a visual representation of such act (book cover illustration). This is precisely what the three participating teachers accomplished by having their students paratextually engage with the science books. Students were encouraged to recognize that the writers of the books had committed themselves to telling a science story, providing a factual science report, or both.

Metatextual reading

Unlike the other two teachers, Rosie and her students engaged in transactional metatextuality. Characterized by the occurrence of moral evaluation, this transaction-centered form of reading focused on evaluating whether the narrative resolution of *The Great Kapoke Tree* was morally right rather than scientific accuracy (e.g., the fact that animals cannot verbally communicate with humans as described in the story). Occurrence of this alternative way of evaluating science texts can be understood in terms of the notion of *authorial averral* (Sinclair, 1986). When texts are perceived as being factual, readers expect authors to be responsible for telling the truth and their written statements are interpreted as averrals (i.e., assertions that something is the case or the truth). A relationship of correspondence is expected to exist between what the writer avers and states of affairs in the world.

Factual authors are perceived as misleading when their written averrals do not correspond to reality (Caldas-Coulthard, 1994; Coulthard, 1994). By contrast, in fictional texts, there is no expectation of correspondence in what is averred (i.e., writers do not have to aver what they assert) and the question of whether the text is true (i.e., corresponds to actuality) becomes irrelevant. Fictional writers cannot be accused of misleading because they hold no commitment to factuality (i.e., to stating only what they know to be a fact).

What is particularly noticeable about this finding is that all three participating teachers resorted to hybrid science texts that combined narrative and exposition and could be simultaneously evaluated as having a factual and fictional status, a literary situation also known as *verisimilitude* (Sinclair, 1986). Nonetheless, teachers and students adopted different reader stances toward authorial averral and factuality. Rosie and her students treated *The Great Kapok Tree* strictly as fiction even though its cover was composed of multiple paratextual elements that actually informed about scientific facts of the tropical rainforest. On the hand, Rachel and Debbie ascribed a factual status to their hybrid science books and applied the evaluative criterion of "scientific untruth" when they came across fictional paratextual elements that failed to correspond to reality (i.e., when authors did not aver what they asserted). In doing so, these two teachers distinguished between fictional and factual engagement more clearly and consistently when reading hybrid science books.

Intertextual reading

Both Rachel and Debbie engaged students in the creation of intertextual meaning relations. Rachel negotiated with her students what constituted the "common theme" across the science texts. Debbie encouraged students to comparatively consider the titles of the books ("question title" versus "telling title") and what they revealed about the nature of their respective science texts. By juxtaposing multiple science books, these teachers intertextually created relations and prompted students to comparatively articulate the significance of each text. The emergence of such intertextual is a direct result of the adoption of a multi-textual approach to science read-alouds, a practice consistent with literacy educators' arguments in favor of the use of conceptually related *text sets* (Harste, Short, & Burke, 1996; Camp, 2000; Short, 2004). Further, the use of multiple texts has been shown to foster more flexible conceptual construction and deeper learning (Bråten & Strømsø, 2011; Bråten, Strømsø, & Britt, 2009; Cerdán, & Vidal-Abarca, 2008; Ebbers, 2002; Enfield, 2014). The present study corroborates this literature by showing that reading engagement encompassing multiple texts that cut across disciplines and genres can indeed serve as a springboard for the negotiation of meanings and connections.

Architextual reading

Both Rachel and Debbie resorted to architextual meaning-making centered on transmission (i.e., student reception of textually encoded information). Rachel identified specific stylistic features of the scientific genre (being "about something real") and gave students explicit instructions on how to read a science text (i.e., reading all words). Likewise, Debbie equated reading scientifically to a type of engagement wherein a text was carefully and systematically read in their lexical entirety (all words). Engagement with science books was for the precise extraction of certain scientific meanings.

This finding extends the existing literature beyond implicit socialization of students into the scientific genre. Prior studies of classroom discourse have revealed how elementary teachers socialize young students into the scientific genre

by allowing pupils to make unprompted contributions (Pappas et al., 2003), posing student-centered oral queries that require pupils to express their own conceptual understandings (Oliveira, 2010), and providing participant examples with the generalized *you* (Oliveira, 2011). These strategies have been shown to implicitly encourage pupils to engage in scientific meaning-making (i.e., create meanings in a generalized, impersonal, and explicit manner). However, rather than relying on implicit pedagogical means, Rachel and Debbie provided students with explicit guidance on what the scientific genre looks like and how to engage in the reading of texts of such a genre.

Hypertextual reading

As indicated above, Debbie's reading engagement also included transactional hypertextuality. By theatrically adapting *What Makes a Magnet?* into a hands-on science activity where students physically performed the "fishing" objects with a magnet, Debbie and her students translated textually encoded meaning into a new representational system (gestures and body movements). This practice is consistent with performative (or expressive) reading engagement. Reading scholars such as Sipe (2000; 2002) make a distinction between analytical engagement and performative (or expressive) engagement with texts. When analytically engaged, children seek to understand a text by analyzing particular elements (plot, characters, setting, and theme). In contrast, in performative engagement, comprehension is pursued through means such as dramatizing the text, talking back to characters, talking over the text, inserting oneself or friends in the story, and suggesting alternative plots, characters or settings. Rather than simply understanding the story, students make the stories their own through active participation. This is precisely the type of learning opportunities that hypertextual engagement with the hybrid science text *What Makes a Magnet?* afforded Debbie and her students. By playing the role of the main character, students were encouraged not only to understand but also take ownership of the science story being told (i.e., make the story about magnets their own).

The occurrence of hypertextuality underscores the possibility of theatrical (re)reading of elementary science texts (i.e., science texts' potential to serve as scripts). This theatrical engagement with a science text provides support for Nielsen's (2006) argument that "each script, or text [whether scientific or not], has the potential for reenactment in public in some form, whether the enactment is explicit (in speech or writing) or tacit (changed behavior, for example) (p.9)." This is precisely the potential strategically and skillfully exploited by Debbie. Rather than efferentially extracting meanings from scientific words in a more detached manner, science reading was treated as an opportunity to aesthetically engage with the world of science, offering students the opportunity to take up and to try on the role of scientists. This more involved form of textual engagement encouraged students to read themselves scientifically (to see themselves as inhabitants of the world of science).

CONCLUSION

This study speaks directly to recent developments in educational policy which have promoted a shift toward text emphasis in elementary science. In the US, the Common Core State Standards (NGA Center CCSSO, 2010) call upon developing readers in the elementary grades to engage with increasingly complex informational and narrative texts and learn how to articulate their comprehension in the academic register. As a result, elementary teachers have been placed under increased pressure to foster non-fictional literacy skills by adequately and effectively

integrating text reading with their science units of study. Thus, better understanding how to systematically engage young students with science texts can help elementary teachers meet CCSS science literacy requirements.

Beyond educational policy, better understanding the pedagogical potential of student reading engagement with science books is consistent with the central role that written texts play in science teaching and learning. As emphasized by Sipe (2001) reading is an interpretative activity that takes place within the larger "text" of one's own life experiences inside and outside the classroom. As such, it is hoped that the present study will provide science educators with much needed insight on how to effectively integrate reading with science instruction and offer young learners with richer and more engaging science reading experiences that transcend transmission of factual content.

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APPENDIX

Transcription Conventions

The following notation is adopted in all transcripts excerpts included in the present manuscript:

?	indicates rising intonations
.	indicates falling intonations
CAPS	indicates emphatic tone
[ ]	indicates observer comments
underlining	indicates key features of the provided excerpts.