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# What Can Students Do With the Words They Know? An ELA Teacher Takes on Science

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**Abstract**
The Common Core State Standard and Next Generation Science Standards emphasize language and literacy across disciplines, requiring shifts in teaching practices and inventive approaches. This case study focuses on the instructional decision-making and activities of one uniquely experienced and qualified seventh-grade science teacher, whose English Language Arts background made her approach to vocabulary instruction distinctive, as she selected focus vocabulary and incorporated morphological instruction and lexical enhancement into science teaching practices. Results highlight the differences between content literacy and disciplinary literacy and the pitfalls of applying broad literacy strategies without deep consideration of disciplinary knowledge and requirements and provide examples of naturalistic ways to incorporate morphology instruction into science instructional conversations to enhance students' relational knowledge.

**Keywords**
disciplinary literacy, vocabulary, science, middle level

**Disciplines**
Higher Education | Language and Literacy Education | Science and Mathematics Education

**Comments**
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# What Can Students Do With the Words They Know? An ELA Teacher Takes on Science

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Distinctive practices are needed to teach vocabulary in engaging, equitable ways that emphasize what students can *do* with the words they know (McKeown, 2015). This is particularly important now, when Common Core State Standards CCSS (NGACBP & CCSSO, 2010) promote engaged vocabulary and literacy learning across contexts, and Next Generation Science Standards (NGSS; Achieve, Inc., 2013) require not just definitions but also determining meanings of key terms and domain-specific words/phrases in science contexts. These highly discursive standards require inventive methods and laser focus on vocabulary selection as well as developing students' abilities to use words we teach.

Common Core State Standards and NGSS present opportunities for dynamic changes in research and teaching practice as English Language Arts (ELA) methods for vocabulary learning are critiqued for use in disciplinary contexts. The specialized knowledge of ELA teachers is needed now more than ever, but this does not mean traditional strategies can be applied wholesale to science (Pearson, Moje, & Greenleaf, 2010; Shanahan & Shanahan, 2014; 2008; 2012). Disciplinary literacy is required.

This study analyzed instructional practices of an experienced seventh grade science teacher as she selected focus vocabulary and worked to improve students' word knowledge and ownership through classroom discussion. Certified in special education and ELA, endorsed for elementary and middle school, Ann had taught for 22 years at the time of this study: 17 in ELA fourth-sixth grades and most recently in seventh grade science. Using case study methods we asked: What happens when an ELA teacher takes on science? Specifically, what was Ann's process as she selected vocabulary focus terms and determined methods of vocabulary instruction in science?

**Ann**

Ann's ELA background made her approach unique among science teachers, and the standards focus on disciplinary literacy rendered her skill set especially interesting. She described using a variety of vocabulary discussion and writing activities within science and attributed the "something more" students in her classes didn't have, to lack of transfer of language skills from ELA to science. In our first conversation she expressed a particular stance toward helping students actively apply word knowledge, saying:

> I don't think it's valuable for kids to write a word and write down the definition. I'm really interested in other kinds of vocabulary building activities cause kids need to have things that are very animated. We have to talk about how they apply it when they're writing it. That's a big piece too. (Interview One)

Ann had other markers of interest as well. For several years she had provided professional development and teacher leadership in her school and district, and participated in select national on-site science training and research experiences. These expertise and leadership experiences, combined with extensive classroom practice and unique orientation to literacy and vocabulary in science, rendered her methods worthy of study.

**Background**

Research on literacy within science has increased in the last decade, but current reviews (Jagger & Yore, 2012; Nixon, Saunders, & Fishback, 2012) found few articles exploring how language shapes and supports meaning-making in science. This gap is troubling because oral and written language is the symbol system most often used by scientists (Hand, et al., 2003). But the vocabulary load in science is heavy (Gee, 2005) and scientific language utilizes extensive specialized vocabulary to describe, compare, categorize, and explain. For many students, learning the language of science is a principal obstacle to mastering content (Braund & Leigh, 2012). Increasing vocabulary knowledge in science is therefore essential (Honig, 2012).

Lee, Quinn, and Valdes (2013) advocated integrated science and language instruction that supports students to "'do' specific things with language" (p. 2). Townsend, Filippini, Collins, and Biancarosa (2012) noted that teachers who attend to vocabulary of their discipline help students build word meaning knowledge as well as practical contextual usage, and such authentic use advances learning in science, language, and literacy for all students (Lewis, Dema, & Harshbarger, 2014). Morphological awareness is particularly useful for science because of the ways terms are related, and is enhanced through conversing about words (Kieffer & Lesaux, 2012; Rasinski, Padak, Newton & Newton, 2011). The recoding process that happens when students converse about words, verbally producing meanings (Shore, Ray, & Goolkasian, 2013) builds ownership: when students can perceive word meanings in written text and spoken discourse and use those words correctly in speaking and writing (Kamil & Hiebert, 2005; Nagy &Townsend, 2012). But engaging in vocabulary learning activities frequently and meaningfully enough to build ownership of science words is challenging.

We need to know more about how science teachers address literacies of science, especially experienced teachers (Abell, 2008). We also need more knowledge on how teachers incorporate vocabulary instruction in disciplines (Pearson, Hiebert, & Kamil, 2007) in ways that develop generative abilities (Ogle & Blachowicz, 2002) and occur in naturalistic activities vs. highly controlled experimental conditions (National Reading Panel, 2000). Our analysis of Ann's planning and practices addresses these gaps.

## Frameworks

### PCK, Presence, Reflective Inquiry

Pedagogical content knowledge (PCK; Shulman, 1986) presence (Rodgers & Raider-Roth, 2006) and reflective inquiry (Schön, 1983; Hayden, Rundell, & Smyntek-Gworek, 2013) framed our analysis of Ann's practices. PCK blends content knowledge and pedagogy into understanding how topics are organized, represented, and adapted for diverse learners. Presence is intense involvement and immersion into the teaching experience, with close attention to both subject matter and students' engagement. Reflective inquiry makes presence happen.

Through 12 interviews over three academic years we encouraged reflective inquiry because of its powerful impact on practice (Rodgers, 2002a; 2002b; Rodgers & Raider-Roth, 2006), defining reflective inquiry as "combining thought and analysis with action in practice" (Hayden et al., 2013, p. 395). Reflective teachers "strive to gain strategic knowledge of a situation in order to develop and explore questions, recognize or acknowledge complexity and make adaptations" (Shanahan et al,, 2013, p. 305). They combine knowledge of students, teaching, and content with reflection on student actions and engagement to respond adaptively and advance learning. The goal is to balance deep, varied content knowledge, extensive pedagogy, and management of unpredictable teaching environments while crafting instructional actions responsive to student needs.

Rodgers and Raider-Roth (2006) called this balance "presence:" intense involvement and immersion into the teaching experience. They positioned presence as the link between pedagogical knowledge and that "something more" that is enacted PCK: the embodiment of the reflective teaching process. Presence in the reflective process includes:

> interactions between teacher and students and between students and subject matter. The teacher pays close attention to subject matter and her students' engagement with it,

> attending to the learning process, observing students at work, analyzing and responding with what Dewey [called] ‘intelligent action.’ (Rodgers & Raider-Roth, 2006, p. 279)

Presence is essential for PCK: combining pedagogy and content in ways that honor both content and learners. Reflection makes presence happen, and teachers draw on deep subject matter knowledge, knowledge of learners and learning, and a range of pedagogical skills in order to reflect. We view PCK, presence, and reflective inquiry as mutually supportive, contributory processes enacted in effective teaching practice.

## Literature

We reviewed literature on current standards, disciplinary literacy, and ELA strategies supporting vocabulary learning.

### Standards

Both NGSS and CCSS acknowledge literacy skills are critical to building knowledge in science, and these standards align with specialized views of literacy within disciplines while acknowledging multiple aspects of vocabulary required to develop ownership. The NGSS recommend vocabulary development through inquiry-based science practices, active student participation, and communication using scientific vocabulary. Students should:

- interpret, evaluate, and integrate quantitative and qualitative content presented in diverse formats including science text
- write and orally defend positions using evidence from text and hands-on inquiry,
- pose questions, plan and carry out collaborative investigations
- collect and present relevant support for conclusions and claims

Framed this way, all aspects of science literacy require ability to understand and use specific vocabulary encountered through reading, writing, speaking and listening in science classes.

**Disciplinary Literacy**

Disciplinary literacy brings content-specific considerations to uses of language. New science units are often introduced similarly to other content areas, but text is read differently: typically for facts and procedures. Vocabulary is used for labeling and classification and related morphologically (carnivore, herbivore) (Shanahan & Shanahan, 2012), contrasting with social studies vocabulary which might include people, places, regions, and systems related semantically. Semantic mapping might be appropriate for social studies vocabulary; morphological study for science. Disciplinary literacy recognizes such differences, using strategies targeting relevant types of understanding. For example, since science vocabulary is frequently related by structure and classification, Greek and Latin morphemes and the ways affixes change meaning (prey/predator/predation) should receive particular focus. They provide short-cuts to meaning and comprehension (Shanahan & Shanahan, 2012).

**ELA Methods**

Since "doing science requires talking science," and the vocabulary load of unique words is greater in science than other disciplines, opportunities to use vocabulary are crucial for "an authentic view of science" (Braund & Leigh, 2012, p. 459). ELA studies have identified significant links between interactive instruction and retention of word meanings (Karpicke & Zaromb, 2010; Metcalf & Kornell, 2007) and Blachowicz, Fisher, Ogle and Watts-Taffe (2006) recommended "instruction [that] provides both definitional and contextual information about words as well as multiple exposures and opportunities to use them" (p. 528). With heavy vocabulary load in science, selecting focus vocabulary to support the ability to "talk science" is critical.

Fisher (2007) discovered this in a study with high school teachers who had previously used content literacy methods (word journals, semantic mapping, concept ladders) for teaching science vocabulary, but found that students still scored far below grade level on vocabulary and comprehension. One difficulty was selection of words to learn. Fisher advocated selection based on how critical a word was to understanding necessary concepts, frequency of appearance across other content areas, likelihood students could use context or structural analysis to determine meaning, and reasonable cognitive load.

Coxhead (2011) and Marzano (2004) organized words into families and academic vocabulary groups in order to make cognitive load more manageable, but even these attempts resulted in unworkable numbers of words for classroom implementation, especially for students with learning or language challenges. The Tier framework (Beck, McKeown, & Kucan, 2002) focuses on usefulness of words to be learned, utilizing judgment and expertise of teachers to make such determinations. The framework sorts words into Tier-1: high frequency, well known words, needing no specialized instruction; Tier-2: words used regularly by mature language users that are definable, interesting, and functional because they occur frequently across contexts with multiple meanings; and Tier-3: obscure words for highly specific contexts. Most vocabulary instruction should focus on Tier-2 words, identified by the teacher as having importance, utility, and instructional potential, belonging to conceptual families students understand but need support with to gain precise understanding and develop ownership. Combining Tier recommendations with disciplinary considerations from Fisher (2007) leads to a focus on Tier-2 words and identification of Tier-3 words necessary for certain contexts but requiring less focus.

**Considerations.**

Another important aspect is that teachers understand misconceptions their students hold. Sadler, Sonnert, Coyle, Cook-Smith, and Miller (2013) found significant links between teacher awareness of students' mental models and student learning of science concepts, providing further support for teachers to bring disciplinary considerations to selection of science vocabulary. Students need support to internalize meanings and methods for analyzing and learning words (Snow, 2010). Inquiry methods and engaged word-meaning concept strategies encourage students to make connections while gaining understanding and confidence in the language of science (Young, 2005).

## Methodology

### Design

An instrumental case study design (Stake, 1995) was utilized because of inherent benefits when exploring "a contemporary phenomenon in real-life context" without attempting to "divorce the phenomenon from its context" (Yin, 1981, p. 59). By design, a case study does not assume causality, and this is appropriate since teaching approaches that work in one setting may not work in others (Dyson & Genishi, 2005). Ann's decision-making resided within the context of her science classroom. Instruction will always look different for other teachers in other contexts, but the intent of this research was to identify aspects of this expert teacher's practice that could be usefully offered to other teachers of science, and to researchers who work with teachers. Ann's expertise, background, experience, and stance rendered her interpretations, judgments, and decisions relevant for study of vocabulary instruction in science.

### Data Collection

Twelve open-ended interviews (60-90 minutes) between the first author and Ann were conducted over three years, beginning as she prepared for her third year teaching seventh grade science. Initial conversations explored an extant text: the list of vocabulary terms connected to the required science curricular units. Extant texts are not created by the researcher nor a product of the research experience. They exist as part of the case and “reflect shared definitions concerning each topic” (Charmaz, 2006, p. 37). Such texts provide useful information but have serious limitations, and in this case the limitation was the great number of terms students were expected to learn in a 9-week unit of study. The vocabulary list was a framing element for this research because it was part of the context Ann taught within, and she had to make decisions about the use of this list. It became an “[object] for analytic scrutiny” (p. 39) and Ann and the first author explored the list together, posing and answering questions about each vocabulary term to distinguish categories within the list. This categorization helped us discern how and why the list was developed. Co-constructing these questions and responses insured that the authors had sufficient information to make plausible interpretations, because Ann provided the context while the first author provided information on Tier frameworks that could help with categorization. Because of this joint grounded scrutiny the authors were able to place our emerging analysis within the ~~social and~~ disciplinary context that Ann provided.

Later interviews became more emic (Stake, 2010), following Ann’s conversational lead. She described instructional problems, brainstormed solutions, and illustrated and analyzed instructional activities. Interviews provided insight into Ann’s reflective inquiry and illustrated her presence in teaching moments that enabled her to enact PCK by balancing multiple elements in order to craft instructional actions. Interviews occurred most frequently in the first and third years of the study (see Table 1), as study parameters were established in the first year and then revisited in the final year to insure saturation had been reached. No communication occurred between interviews.

## Analysis

Grounded theory analysis (Glaser & Strauss, 1967; Charmaz, 2006) illuminated how Ann reflected on and interpreted instructional experiences and made decisions that led to instructional actions. Rather than word-by-word or line-by-line methods, in our first stage of analysis we coded for critical incidents: times in interviews when Ann used more than one sentence to describe a particular event. Transcripts from Year One interviews were initially read closely by the first author, a literacy professor with 17 years of K-12 teaching experience. The intent of this first round was to draw attention to topics Ann spent time with during reflective inquiry (Charmaz, 2006). We utilized Tier (Beck et al., 2002) and disciplinary literacy (Shanahan & Shanahan, 2008, 2012) frameworks when analyzing Ann's vocabulary selection and instructional decisions.

During Year Two the second author, a PhD candidate in science education with 13 years experience teaching middle and high school biology and chemistry, joined the project. At end of Year Two author one analyzed transcripts from that year, and Years One and Two were independently analyzed by author two using the same open coding for critical incidents. This second round uncovered ways Ann combined all tools at her disposal: content and disciplinary knowledge, pedagogy, and knowledge of learners to make instructional decisions and take action. Both authors then engaged in consensus conversations around each independent coding foray to identify themes. This dual coding (Barry, Britten, Barber, Bradley, & Stevenson, 1999) helped insure validity of the coding scheme and was used for all levels of analysis.

As we began to write, we worked to weave the data back into a coherent whole (Charmaz, 2006) using Ann's descriptions to show how she utilized reflective inquiry and presence to think deeply about content and students, and how she enacted PCK by applying instructional pedagogy flexibly to content as well as needs of particular students (Hayden et al., 2013). Three additional reviews of each interview by the first author, including Year Three of data collection, resulted in extensive analysis of Ann's actions. Because no new codes emerged in Year Three, we judged saturation had been reached.

## Results

Two major themes emerged. First, analysis of Ann's instructional decision making, influenced by her unique intersecting ELA and science pedagogies, illuminated critical distinctions between disciplinary literacy and content area literacy (Shanahan & Shanahan, 2012) and the insufficiency of utilizing the Tier framework (an ELA method) without concurrent consideration of science disciplinary literacy. Second, Ann's case provided specific examples of instructional conversations with students promoting morphological connections. Understanding these connections among science words is crucial for understanding science content, but examples in practice are rare and necessary (Beck, 2010; Ogle & Blachowicz, 2002; Pearson, 2010).

### Critical Incidents for Vocabulary Selection

During reflective inquiry Ann utilized specific types of disciplinary knowledge to analyze curriculum and plan effectively. In Year One, with considerations of cognitive load in mind (Fisher, 2007), Ann chose ten words per semester to emphasize. But when confronted with 37 district-required words for unit one (Table 2) she questioned this decision. Thirty-seven required terms challenged notions of cognitive load, and constraints of a nine-week unit raised questions regarding how to provide repeated encounters with all words in supported contexts (Nagy & Anderson, 1984).

#### Tier analysis.

Although the Tier system has not been extensively studied with secondary science, when Ann applied it to the 37-word list during Interview Two, it did assist with initial classification. Some words were Tier-1: already known by seventh graders (earthquake, volcano, lava). Conversely, some were Tier-3: appearing only in specialized contexts (asthenosphere, lithosphere).

The Tier framework advocates focus on Tier-2 words in order to leverage students' partial knowledge into ownership. For this research, Tier-2 were those words students needed to know as they progressed through upcoming years of science. Words having different meanings in other contexts (crust, mantle, compression, pressure) or high frequency words for science (granite, inner/outer core, magma, rock cycle) were good candidates, as were words that were partially known. Ann employed Tier analysis by applying her knowledge of students' mental models (Sadler et al., 2013) to each term on the list, as in this vignette:

> What helps me is, this is Tier-2: words that I think they might have heard, might know something about. Okay? I mean they might know something about destructive forces and constructive forces. When you destruct you tear things down. There might be two or three they have some knowledge about but lithosphere, asthenosphere, they're probably not going to know at all. (Interview Two)

But Tier-2 criteria was only Ann's first level of analysis.

**Disciplinary analysis.**

Ann shared extended descriptions of science knowledge expected in seventh grade and beyond, using curricular tools and disciplinary knowledge to expand her analysis. This included what students would need to know in upcoming science assessments.

> I'm looking [at] objectives for the whole year, the things highlighted will be tested in eigth grade. So when it says, 'Identify, compare and contrast layers of the Earth' they need to know crust, mantle, outer/inner core. And with mantle there's lithosphere and asthenosphere. I think they have to be aware of them, and know they exist. When I was developing my [instruction] today that was the piece I thought I'd add, "What makes up the mantle?" because they have to know there's a lithosphere, asthenosphere, lower mantle. The lithosphere also works with the crust. And they're going to have to know the rock cycle. They need to know what seismic waves are, [and] constructive/destructive forces. The only two I really need to think about are do I really want them to know lithosphere and asthenosphere as [Tier-2 10-word list] or if knowing them within the context … I'm thinking that is enough. So lithosphere and asthenosphere may not be on my [Tier-2 list]. (Interview Two)

While author one immediately considered "asthenosphere" and "lithosphere" as Tier-3 words warranting less focus, Ann did not treat the task so lightly. She brought disciplinary analysis to examination of district-required words, evaluating Tier categories against what she knew about science. The tension this created was crucial in order for her to reflect critically on what students needed and how her instruction could guide them. A content area literacy approach might presume that the Tiers would be sufficient for this task. Such an approach minimizes the extensive disciplinary knowledge Ann used.

Tier and disciplinary literacy frameworks bring different bodies of knowledge and expertise to a task. Ann applied them in tandem. This incident illustrates subtleties of disciplinary literacy that cannot be fully considered by those who do not work daily in that field. Ann's disciplined analysis of content helped her design instruction that could lead students to detailed knowledge and ownership of critical science vocabulary. Her selection of words for additional emphasis helped her focus instruction and consider cognitive load, giving special emphasis to words that were *repeatable* (Fisher, 2007): likely to be used again within science. Concurrently, she implemented daily practice of Tier-3 words (asthenosphere, lithosphere) meeting criteria for *representativeness* (Fisher, 2007) of a critical science concept: understanding what makes up the mantle. Ann reflected on vocabulary selection decisions in 11 of the 12 interviews, and after initial analysis her intentional use of vocabulary in daily discussions along with specific instruction helped highlight detail in students' lexical knowledge, building concept knowledge and meaning relationships.

**Critical Incidents for Morphology Conversations**

Ann collected and analyzed student data to inform her understanding of students' misconceptions (Sadler et al., 2013), enhancing her ability to be present to students' learning and make instructional decisions. One data collection method she developed was a practice activity she called S4V8 (Study 4 Vocabulary: 8 words). During the first five minutes of class, three times/week, students reviewed vocabulary terms independently. Ann randomly drew and read eight definitions while students wrote down the matching words. Students graphed daily performance, and class totals were graphed. This well-worn vocabulary technique provided Ann with a window into students' knowledge and misconceptions, and she used these events to highlight and enhance detail in lexical knowledge.

> We were doing "predation" because they knew "predator" and "prey". Someone said, "I wrote 'predator' instead of 'predation,' is that okay?" I said, "You're still talking about one organism that kills another. I was looking for 'predation' but if you had 'predator'

that's okay. If you had 'prey' would that be right? No, because that's not an animal that kills another animal." (Interview Six)

The student response "predator" was an imprecise label for the definition Ann provided. But she accepted this response, using it to shape and refine knowledge of "predation" by highlighting "predator" as a stronger response than "prey." Here, she relied on one aspect of morphology: relational knowledge (Tyler & Nagy, 1989; Kieffer & Lesaux, 2012) highlighting the common relationship in form and meaning. "Predation" and "predator" are derived from the Latin "praeda:" prey, plunder. Ann explicitly drew students' attention to this relationship, establishing another connection among these words, and did so in a naturalistic way during instruction.

Ann's presence to her students' attempts at morphological analysis led to scaffolding opportunities and served as invitations for students to apply word-learning skills to science. She used similar techniques to connect "divergent" with "divide" and, less precisely, "convergent" "compressed" "compression."

> One of the things [curriculum] talked about was snow on Antarctica becomes compressed, so when they got to that part, they were taking notes and I said, "So the [snow] becomes compressed. What does that mean to you?" Someone raised their hand and said, "Well, that's like pushed together." I said, "Where else have we learned something about compression? What boundary were we talking about?" "Oh, that's a convergent boundary." So I said, "See, you can make connections with the thing you learned before and use a word, and now you have a visual too because you can see the snow that's compressed. As it gets compressed it turns into ice and you have an ice sheet

> instead of snow in Antarctica. So anytime we're using the language, using it in just another manner expands their vocabulary I think. (Interview Three)

What these instructional conversations lacked in precision was made up for in illumination of semantic and morphological relationships. Discussions allowed students to play with relational knowledge and develop visual images to support understanding. They provided "definitional and contextual information" (Blachowicz et. al, 2006, p. 528) and "content that students have a reason for wanting or needing to understand" (Carlisle, Fleming, & Gudbrandsen, 2000, p. 186). Ann foregrounded these relationships during discussion, bringing ELA pedagogy to science literacy.

Ann used the same word study approach, with enhancements, to build vocabulary knowledge for students with learning challenges. Removing requirements for exact spelling, she focused on constructing concept knowledge, as in this conversation about "carnivore:"

> [I said] 'Now, think about this. What connections can you make to this definition?' [Student looked] at me and I said, 'Consumers that eat only animals what is that?' [Student said] "Well, I know it's a carnivore but I don't know how to spell it." I said, "It's not a spelling test. Just write down the word and give yourself graph credit because you know it" and then he wrote c-a-r-n-i-. That's perfectly fine. (Interview Six)

Ann highlighted detail in this students' lexical knowledge and built concept knowledge and meaning relationships, without letting him stumble over spelling. By encouraging him to write what he could, Ann provided a scaffold, allowing him to commit to his partial knowledge (Sadler et al., 2013), and a schema to build on in later discussions. Ann paid "close attention to subject matter and students' engagement with it." (Rodgers & Raider-Roth, 2006, p. 279). Her ability to tease out extraneous elements like perfect spelling, focusing instead on developing ownership of words, helped her be present to students' experience of curriculum.

## Discussion

Ann leveraged her intersecting pedagogies (ELA and science) when she took on science teaching, and our analysis revealed how that impacted instructional decisions. First, it illuminated critical distinctions between disciplinary literacy and content area literacy (Shanahan & Shanahan, 2012). Tiers (Beck et al., 2002) alone were insufficient without extensive consideration of disciplinary literacy for science. Categorizing Tiers did not provide enough support for vocabulary selection and instructional decisions Ann needed to make, and her additional knowledge of science objectives, content sequence, and conceptual connections was crucial. This has implications for curriculum developers, especially as standards move toward literacy across content areas. This work cannot be done by literacy or content professionals alone. We must work in disciplinary partnerships.

Secondly, Ann's case provided specific examples of instructional conversations promoting morphological connections with students. While vocabulary assessments are frequently based on assumptions that students will recognize related words if they are familiar with one member of a family (consume, consumer, consumption) (Hiebert, 2005, 2006), the research evidence describing morphology conversations during secondary science instruction is sparse. Ann provided evidence of naturalistic morphology instruction through classroom discussion. Beck (2010) and Pearson (2010) have called for such examples, and Snow (2015) has emphasized the need for views of how teachers implement research-based practices.

To develop her students' flexible and multi-faceted ownership of key science vocabulary Ann leveraged Tier considerations with disciplinary concerns, using the tension this created to think critically about what students needed to know, short and long term. These decisions required Ann to combine her understanding of the nature of words and language (Carlisle, Kelcey & Berebitsky, 2013) with her specific understanding of authentic science contexts. Across all 12 interviews she continually weighed the knowledge demands of science against available literacy methods. She grouped science words thoughtfully, implemented instruction that gave special focus to relational connections, explicitly drew students' attention to morphological connections, discussed them, and revisited them often. She provided scaffolds for her students, accepting partial knowledge and removing the need for perfect surface skills, so they could refine lexical and relational knowledge and use the words they knew.

These findings point to the need for thoughtful, ongoing, inclusive consideration of disciplinary literacy, and for more research that describes how teachers incorporate vocabulary instruction into disciplinary classrooms to develop independent word learning abilities. The National Reading Panel (2000) called for examples of generative vocabulary instruction in practice, noting that we know much about vocabulary instruction in highly controlled conditions, but not enough about how this occurs in natural instructional contexts. The need for such examples of practice is pressing (McKeown, 2015; Snow, 2015). This study describes specific ways Ann engaged in naturalistic dialogue with her students that focused on refining lexical knowledge and increasing relational knowledge of disciplinary vocabulary, and offers a view of one teacher's practice in selecting and incorporating disciplinary vocabulary into daily instructional conversations.

## Conclusions

Our focus on the activities of one teacher means that broad generalization is not possible. However, Ann's expertise, background, and experience render her methods of analysis, interpretations, and actions in the science classroom relevant and worthwhile to researchers and teachers. Challenges for building literacy across disciplines are complex, and views from all sides: teachers, students, and researchers, will be necessary to craft effective instruction. Ann's specialized knowledge of her two pedagogies went well above what literacy research or even science research alone can encompass, but this research shows once again how teacher-researcher partnerships can bridge theory-to-practice gaps and result in outcomes that shape ideas, build knowledge, and add to the body of knowledge on teacher decision making and disciplinary literacy within science.

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