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"See, You Can Make Connections with the Things You Learned Before!" Using the GRR to Scaffold Language and Concept Learning in Science

H. Emily Hayden
Iowa State University, haydenemily4@gmail.com

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Abstract

This chapter details the methods one expert teacher used to make her own learning the object of inquiry, simultaneously developing the insights and the strategies she needed to mentor students. It describes how Ann infused the GRR into planning and instruction to create learning experiences that insured student success, even if only at incremental levels. Ann’s methods can thus become a model for other teachers who wish to enhance their students’ learning of science language and concepts through infusion of literacy activity.

Keywords

Disciplinary literacy, science, language, gradual release of responsibility, inquiry-based instruction, science conceptual knowledge

Disciplines

Educational Methods | Educational Psychology

Comments

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"See, you can make connections with the things you learned before!"

Using the GRR to scaffold language and concept learning in science

H. Emily Hayden

Iowa State University, Ames, Iowa

> "I am all about bringing as many science experiences into the classroom from outside the classroom as I can. It is about reaching out and helping students see science as a career choice for them, and discovering their world outside the box of the classroom. That's my ultimate goal."

Ann, the seventh-grade teacher quoted above, sets a worthy, challenging goal. There are persistent, significant achievement gaps in science scores across race, ethnicity, and gender lines. Students perceive their possibilities for success in science very differently depending on who they are, and self-efficacy, identity, and achievement are all impacted by these perceptions (Berends, Lucas, & Penaloza, 2008; Philips, Crouse, & Ralph, 1998). For example, girls report a significant drop in enjoyment of science as they move into middle grade years (Riegle-Crumb, Moore, & Ramos-Wada, 2010) and the National Assessment of Educational Progress (NAEP) reveals discouraging results for disaggregated groups (Keiffer, Lesaux, Rivera, & Francis, 2009). Given this situation, how can a science teacher engage all students in science inquiry that builds interest, helps them discover their world outside the classroom, and leads to increased science knowledge?

When language and science inquiry coexist, science knowledge is enhanced (Pearson, Knight, Cannady, Henderson, & McNeill, 2015). But the highly specific, esoteric language of science presents significant barriers to science learning (Brown, Ryoo, & Rodriguez, 2010; Gee, 2005), and Keiffer et al. (2009) proposed that "all sophisticated academic tasks, [including] reasoning with scientific information, are mediated by language and literacy skills" (p. 1188). Recognizing this challenge, researchers have proposed that science conceptual knowledge and science language should be developed concurrently (Pearson, 2010; Haas, Hollimon, & Lee, 2015) in ways that transcend difficulties posed by the sometimes obscure language of science (Brown, et al., 2010). Pearson, Moje, and Greenleaf (2010) described ways to make explicit connections between science language, concepts, and science knowledge. Here, I describe research focused at the point where language merges with concepts, and scaffolding is the key.

This chapter explores the work of one seventh-grade science teacher, Ann, as she used the Gradual Release of Responsibility (GRR) to develop students' knowledge and use of science language to build science conceptual knowledge. Using classroom discussion and writing as tools for science inquiry, Ann forged connections between the disciplinary language of science and concepts labeled by that language. I worked in a researcher/teacher partnership with Ann over four school years, collecting data that included interviews, Ann's teaching journal, student artifacts, and vocabulary pre/post assessments. Ann and I worked in tandem, leveraging the specialized knowledge each of us possessed to study teaching and learning science language and science concepts.

The Gradual Release of Responsibility

Ann employed thoughtful definition, classroom discussion, and writing frameworks as scaffolds to advance students' knowledge and use of science language and science concepts. Scaffolds refer to the supports and techniques a teacher utilizes to help a learner gain new learning: to make the move "from what they can accomplish [independently] to what they can accomplish *with a little boost*" (McVee, Shanahan, Hayden, Boyd, & Pearson, 2018, p. 3). Scaffolding is a key element of the GRR. As outlined in Chapter 1, the GRR has grown well beyond its humble beginnings as a description on a napkin, becoming the predominant model to illustrate how teachers co-construct knowledge with students and how students appropriate that knowledge for themselves. As the GRR model has evolved, ways of conceptualizing it have evolved as well. Modeling and scaffolding components are particularly relevant to the research described in this chapter, and the data provide examples of instruction in the Region of Shared Responsibility (McVee et al., 2018, p. 7) and Collaborative Use of the Strategy in Action (McVee et al, 2018, p. 8).

Brown and colleagues (2010) described the value of using students' language, even though it may be less formal, to develop science conceptual knowledge. Ann's classroom discussions focused on constructing real-world examples of science concepts and attaching science-language labels, defined in student language, to those concepts. This helped Ann's students appropriate science knowledge for themselves, and they demonstrated their knowledge in writing, both on a vocabulary assessment we developed and in science journals. In these examples of productive vocabulary use students applied language strategies Ann modeled during discussion, and they moved toward Primarily Student/Independent Use as depicted by McVee and colleagues (2018).

Pearson (in McVee et al., 2018) raised instructional questions inherent in the GRR model, including:

- Under what conditions of scaffolding can students do X?
- How can a teacher fade scaffolds over time to lead to completely independent performance?

I explore these issues with specific questions about Ann's instructional practices: 1) How does Ann provide "just the right amount" (McVee et al, 2018, p. 10) of explicit instruction? 2) How can she tell that students are appropriating science language and concepts for their own use?

This chapter is divided into three parts. First, I provide a brief, broad overview of vocabulary learning theory, describe my research partnership with Ann, and report results of a theory-based classroom assessment of science vocabulary we created. Next, I describe and analyze methods Ann used to incorporate science language into science inquiry, classroom discussion, and science writing. The chapter ends with implications for instructional practice.

Part 1: Theory and Assessment of Science Language

Vocabulary Research

Instruction focused only on memorization of words without connection to concept learning will ultimately fail in science, as it does in general contexts (Fisher & Frey, 2014; Lesaux, Keiffer, Faller, & Kelley, 2010). Alternatively, teaching practices that merge literacy with inquiry-driven science instruction engage students in "a process of actively making meaning of science" (Pearson et al. 2010, p. 460) and this increases the likelihood that students will retain the language learned in the process. Such meaning-making requires teachers to thoughtfully engage the language of science, actively building connections between a word and the concept it labels. This is not typical for vocabulary instruction in United States classrooms. Instead, we focus on memorizing lists of words, sometimes related to content and concept learning but sometimes seemingly arbitrary. Word knowledge is assessed at the end of a week or a unit and is not revisited. But word knowledge is complex, with aspects including incrementality, multi-dimensionality, polysemy, interrelatedness, and heterogeneity (Nagy & Scott, 2000). Reflecting this complexity, instruction should also be multifaceted and complex to result in long-term retention of words.

My research with Ann used two aspects of word knowledge as theoretical frames. Incrementality acknowledges that knowing a word is a matter of degree, not “all or nothing”. Students may know that “response” has something to do with behavior or action, but may not know that in science a “response” is involuntary and connected to some kind of stimulus. Two sentences from the data demonstrate the difference: “I clapped my hands and everyone clapped as the response” does not define “response” as used in science. However, “My response to the loud, sudden sound was to jump a little” comes closer. As students refine knowledge of a word they build and elaborate schema for that word. Knowing a word proceeds by degrees, as meanings are enhanced and elaborated: it is incremental.

Multidimensionality acknowledges that there are different ways one can know a word. A word can be known in spoken or written form, by conceptual meaning, associated with a context or with other words, as part of a morphological word family, and so on. For example, a word like “abiotic” may be recognized and decodable if the “bio” morpheme is known because the other morphemes (“a” and “tic”) are easily decodable. But knowing how to decode and pronounce “abiotic” and even recognizing “bio” as something to do with “life” does not mean a student can use the word correctly in writing or discourse. “Abiotic” is “characterized by the absence of life” (dictionary.com), so students would need to recognize that the “a” is being used as a prefix that means “not”, as in the word “atypical”. Some students would make this connection on their own, but many would benefit from discursive approaches to learning and applying the meaning of this word, even if they could decode it and determine the meaning. There are many dimensions to knowing a word.

Partnering with Ann to Explore Language in the Science Classroom

Practice Embedded Educational Research (PEER) (Snow, 2015) frames my partnership with Ann. PEER is a methodology for bringing rigor and realism to educational research, and the critical foundation is acknowledging the intriguing and challenging problems of teaching practice and research that do not fit analytical models espoused by "basic science" (Snow, 2015, p. 460). These problems are no less valid as inquiry subjects than laboratory research questions, but are valued less by the research community at large and some grant funders in particular. Snow urges researchers to modify the traditional approach of identifying a problem from gaps in the research literature and instead explore "pressing concerns of practitioners" (p. 461).

PEER emphasizes working in partnership with teachers to explore problems of practice in their natural settings: classrooms. By doing this, researcher/teacher teams can leverage "the interconnections of research and practice [versus] the gap" (p. 460) and can improve teaching practice by studying how innovations are developed, implemented, and evaluated in classroom application. PEER underscores listening to what teachers say about interventions, using an iterative process to develop more useful and usable versions of evidence-based programs. In PEER partnerships, changes to an intervention are not viewed as problems, but are framed as refinements based on practical application, evidence from real teaching, and the expertise of the teacher. These tenets became the landscape for my partnership with Ann, and we each provided expertise necessary for the success of students and the success of this project.

Constructing a vocabulary assessment.

One of our first tasks was development of a classroom assessment to capture growth in science vocabulary knowledge. We began by collecting and reviewing standards and curriculum documents. Ann was the expert for this review and I accepted her appraisals, basing my trust on the particular and extensive markers for expertise she possessed in content knowledge (science), pedagogical knowledge (teaching), and pedagogical content knowledge (at the intersection of content and teaching) (see Hayden & Eades-Baird, 2016; 2017 for full description).

We worked together to select high-utility science words for intensive instructional focus, basing selection decisions on Ann's knowledge of standards and curriculum and of the characteristics of her seventh-grade students. I brought the Tier framework (Beck, McKeown, & Kucan, 2002) to our work as a way to organize all the words required by the science curriculum for each unit of instruction. Through many discussions we determined which words were Tier-1, readily known by students and not needing further instruction; which were Tier-3, highly specific to the topic being studied and unlikely to be found in other contexts, science or otherwise; and which words could be classified as Tier-2, likely to recur in science learning and general knowledge, or those with different meanings when used in science, (e.g. "force").

Once we sorted words collected from standards and curricular documents into Tiers, Ann selected 10 words per semester for special emphasis in instruction and for use in the vocabulary assessment. These were Tier-2 words, likely to recur in future science learning and general science knowledge. Together, we constructed a pre/post assessment for each semester of the seventh-grade year using the 10 Tier-2 words Ann identified, with four items for each word. Design of the assessment was something I brought to the partnership, and was adapted from cott, Hoover, Flinspach, and Vevea (2008). It was constructed to incorporate incremental knowledge, using the four items for each word as scaffolding to refine knowledge incrementally toward mature understanding. Items were both receptive and productive, tapping multi-dimensional ways of knowing each word.

Table 1 provides a sample from the vocabulary assessment. Question 1 provided a baseline for students' self-reported knowledge of each word. Questions 2 and 3 provided scaffolded opportunities to demonstrate knowledge of a word and served to activate schema through progression from choosing a one-word definition (Q2) to choosing a sentence length definition (Q3). This sequence was intentional, with goals of capturing the incremental nature of vocabulary knowledge and addressing multidimensionality by activating semantic and syntactic networks to access word meaning. While Questions 1, 2 and 3 are receptive in nature, providing multiple choice options for students to choose from, Question 4 provides an assessment of productive knowledge: asking students to write a sentence for the focus word and thus demonstrate their ability to use it correctly in written language. These are essential aspects demonstrating ownership of a word (Kamil & Hiebert, 2005; Nagy, & Townsend, 2012) "when students can perceive word meanings in written text and spoken discourse and use those words correctly in speaking and writing (Hayden & Eades-Baird, 2016, p. 184).

Results of the Vocabulary Assessment.

Ann teaches in a lower-middle class, moderately educated Midwestern city (census.gov). At the time of data collection her school served approximately 800 students per year in grades 6-8, where 81% of the students were white and 26% qualified for free/reduced lunch. Our sample was nearly evenly distributed with 64 males and 62 females.

Student results were analyzed for spring semester of two consecutive school years. Mindful of Snow's (2015) call to "[watch] how new tools get used and [listen] to what teachers say about them" (p. 461-462), this assessment evolved as Ann observed and reflected on its usefulness for her students' learning. We made changes to the words on the assessment, based on Ann's refinement of her practice and adaptive judgments of the language understanding that was most useful to her students as they built conceptual knowledge. The final data set included pre/post scores from spring semester of two consecutive school years when the same words were used each year. Topics for spring semester included living organisms, behavioral inquiry, and environmental science.

Question 1 provided a baseline for students' perceived knowledge levels and supplied some useful information to Ann as she began each instructional unit. She reported high occurrences of students overestimating their knowledge of the words. A brief comparative analysis confirmed this. Since this information did not contribute materially to the research, it was dropped from the analysis. Questions 2 and 3 provided scaffolded opportunities to demonstrate incremental growth in knowledge of each word, from choosing a one-word definition to choosing a sentence length definition. These produced binary item scores (correct/incorrect), while Question 4, which asked students to write a sentence using the focus word, yielded an ordinal score. Sentences were scored on a 0, 1, 2 scale, and I utilized the expertise of my frequent co-author, Michelle Eades-Baird, who is a science education professor, biologist, and former middle school science teacher, to complete the scoring (Hayden, Eades-Baird, & Singh, 2018). A sentence for "response" needed to describe both the stimulus and response and demonstrate that a response is involuntary to earn a full score of 2. From the data, the student sentence "When I felt a bug on my arm I reacted from the stimulus to swat it off" earned a score of 1 since it demonstrated some understanding of stimulus but characterizes the response as planned, not involuntary. The student sentence "When someone claps right in your face you blink" earned a full score of 2 since it demonstrated more complete seventh-grade knowledge of "response" as involuntary and included both stimulus and response.

Multinomial logit regression for Question 4 yielded results that support the incremental nature of vocabulary learning and the value of a scaffolded assessment. This method of statistical analysis is used when one or more independent variables could influence a dependent variable. Our dependent variable, or outcome, was sentence writing (Question 4), which could be scored at three levels (0, 1, or 2) and we wanted to explore the relationship between the independent variables of Question 2 (one-word definition) and Question 3 (sentence-length definition) and sentence writing. Did students' performance on Question 2 or on Question 3 have discernible influence on students' sentence writing score? Controlling for all factors, improvement in response to Question 3 (sentence-length definition) increased the odds of writing a sentence that earned a full score of '2' by 21 times in post-test. Additionally, improvement in response to Question 2 (one-word definition) virtually guaranteed a full score of '2' on sentence writing at post-test.

Since improvement is expected with any instructional intervention and these data were collected from students in one science teacher's classroom, we make no claims of generalization. However, it is encouraging to note that females performed just as well as males on this assessment: No significant differences were found in our nearly equally divided sample. Previous vocabulary research has found less robust performance for females than males (Snow, Lawrence, & White, 2009) or does not report disaggregated results (McKeown, Crosson, Moore, & Beck, 2018). The scaffolded responses (Questions 2 and 3) not only captured the incremental growth in receptive knowledge of a word, they also supported and refined the ability to use that word effectively in a productive sentence writing task.

Part 2: Incorporating Language into Science Inquiry, Discourse, and Writing

Any assessment tells only part of the story. This vocabulary assessment was completed at the end of the semester, sometimes weeks after the corresponding unit and it provided part of the data for our question exploring students' appropriation of science language and concepts for their own use. I was also interested in other indicators Ann considered as evidence of student learning and how she provided "just the right amount" (Ch. 1, p. 10) of scaffolding for her students, removing it as soon as possible.

In this section I describe ways Ann worked to enhance literacy practices for science learning during her instruction. Most of her actions used science language in informal ways to build concept knowledge, and she accepted students' own language as they worked to build this knowledge. In this way, she exhibited the disaggregated methods described by Brown et al. (2010). She followed a progression in the level of scaffolding she provided, which was extensive at first and included frequent modeling. Her instruction evolved from definition activities with one correct answer, to elaborating responses in extended classroom discussion, to providing opportunities for students to use science language independently in their own discussion and writing.

Directive and Heavily Scaffolded

Once we completed our initial work reviewing the language for seventh-grade science, Ann developed student friendly definitions for the Tier-2 words on the vocabulary assessment and for the word lists provided for each unit of the science curriculum. To give regular practice with the words she developed a five-minute activity she implemented three to four times per week. These brief dips into the language were a way for students to develop a basic level of knowledge that Ann could then elaborate on during class discussions, and that students could ultimately use in their own spoken and written language.

Ann placed her student-friendly definitions into a cardboard box at the front of her classroom. As she completed daily start-of-class routines students studied their science notebooks which included all the words and their definitions. Ann then drew 10 random *definitions* from the box, asking only that students write the matching word. She accepted partial knowledge of a word, and misspelled or partial spellings. Ann's description of her response to a student's question about the word "predation" offers an example of partial knowledge and the instructional opportunity it provided.

> 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.'' (Hayden & Eades-Baird, 2016, p. 193)

"Predator" was not completely correct, but it was a stronger response than "prey." This imprecise label for "predation" gave Ann an opportunity to further develop students' concept knowledge. She scaffolded this response for "predation", building concept knowledge by establishing that "predation" occurred in the same context as "predator" and "prey". She modeled how a more experienced language user leverages context to think about connections between words.

Ann provided further scaffolding for her students by removing the requirement of perfect spelling from this shared construction of word and concept knowledge. By doing so, she structured the definition activity to focus on a more important goal: developing knowledge of science language and connecting language to concepts. When the word was "carnivore",

> [I said] 'Now, think about this. What connections can you make to this definition?" [The 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. (Hayden & Eades-Baird, 2016, p. 194)

Ann’s acceptance of partial knowledge and partial spelling scaffolded the learning of all her students, but was especially supportive for students with learning challenges. Her focus was on developing labels and attaching them to science concepts, and she did not allow spelling to become a stumbling block on the way to this goal. She modeled her thinking as a more mature user of science concepts and language, and she leveraged the opportunities provided by these brief definition activities to build knowledge incrementally and in multidimensional ways.

Figure 1.9 in Chapter 1 depicts the region of shared responsibility for learning: when teacher input and student input overlap and both teacher and student share in construction of knowledge. Ann utilized definition activities as a time for informal language practice, when students could construct knowledge using their own language and demonstrate their developing knowledge without the need to be perfect. Although these definition activities were somewhat directive the stakes were very low, since Ann did not check student responses. Students recorded the words that matched the definitions she read, and graphed their score in their science notebooks after Ann read out the matching words.

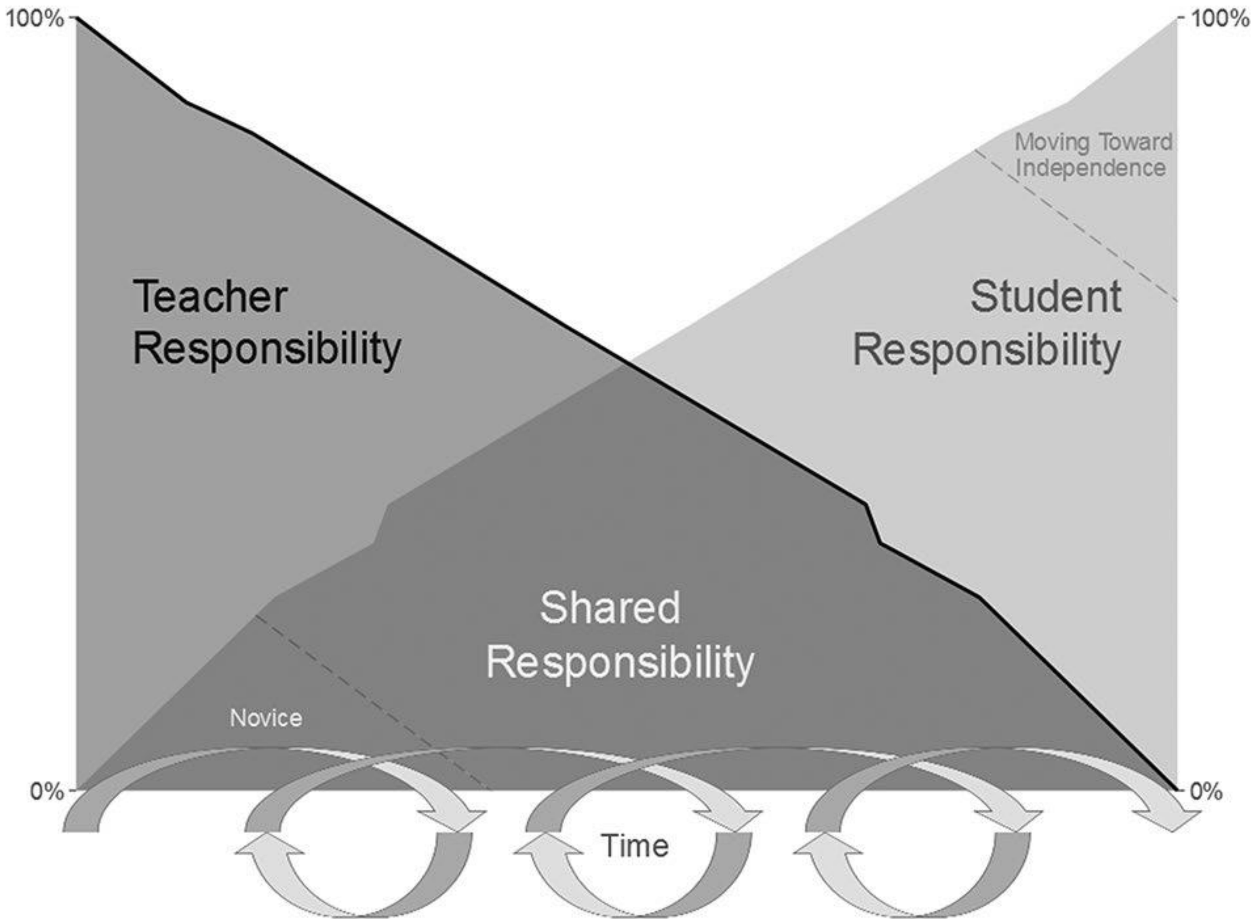

Figure X. Teacher and student responsibility in the Gradual Release of Responsibility over time.

Elaborating on Student Responses and Questions

Moving from this definition activity, Ann incorporated language into classroom discussion around science concepts and inquiry. Again, she scaffolded heavily at first and started with the easiest examples, as described below.

> Melting was one of the words yesterday and so it was going from a solid to a liquid and someone said “sublimation”. I said, “Okay, let’s talk about sublimation again, not solid to liquid. What is that?” And someone else said, “Well, solid to gas.” I said, “Let’s think about outside right now. How many of you, last weekend, built a snowman, a snowperson, a fort, whatever it is. You’ve watched that fort [or snowman] shrink over time and … there’s no water, so what’s happening? The water is evaporating, changing to

> a gas, it's getting smaller. That's sublimation." So, … [talking] about it in the context of what they're doing right now.

She provided more concrete support in a class including multiple students identified with special education needs: "we drew pictures of a snowman and then we made the snowman shrink in our pictures, made him look like he was shriveling. I tried to [use] the snow because that's the easiest [example]."

Students' confusions and knowledge gaps provided additional elaboration opportunities Ann used to develop science concepts, scaffolding students' "emerging and incomplete thinking" (Loewenberg Ball, Thames, & Phelps, 2008, p. 401) by modeling a problem-solving stance. The following vignette occurred during an inquiry project that involved growing vegetables from seeds.

> [Students said] "What am I supposed to do with this? Do you need to have the root?" [I said] "I think we do." "What if it breaks off?" I said, "Well, what do you think will happen?" And they're so excited now because we're going to grow radishes and lettuce, and they say, "Will we be able to eat it?" [I say] "Well, I've never done this before. Maybe we will and maybe we won't, let's see!" (Hayden and Eades-Baird, 2017, p. 49)

Ann used students' questions and incomplete understandings as an opportunity to model a questioning stance. She introduced scientific investigation techniques: guiding students to ask questions and setting up an inquiry project comparing the growth of radishes and lettuce from seeds. Along the way she developed connected concepts: hypothesis, variables, and the scientific method. Her responses to students' questions and misconceptions provided authentic opportunities to explore science concepts. These types of classroom activities, combined with opportunities to collaborate with peers, ask questions of the teacher, and work together to build background knowledge can significantly impact student engagement and learning (Taylor et al., 2016).

Independent Student Use

Incorporating writing into science inquiry came naturally to Ann. She enjoyed reading students' writing, and believed that "having students share summaries of their learning is a good way to see how they use the language and understand the content." She used students' writing after inquiry lessons to evaluate learning of concepts, explaining, "I look for their understanding of vocabulary and content in their projects because they can apply what they have learned creatively." This added to the evidence of student learning she gathered from discussions, "When I hear them using the term in our class discussions, then I know they understand the meaning of the word. I also can assess their learning when they use it correctly in their writing."

When it came to independent use, Ann hoped that her efforts to build knowledge by defining and talking about science and connecting language to concepts would "help them think about how they can write it on their own." She did not always model sentences connected to specific content though, "because … if I show them a sentence, [I'm] going to get 60 sentences just like that. I don't want them to duplicate my sentence … I'd rather have them think on their own, but [I want to] give them the tools to be able to do that." As with definition activities, Ann accepted approximations and partial knowledge, and she described the incremental steps toward concept knowledge that she observed: "I see sentences from simple definitions, to trying to make a sentence work, to complete thoughts being described." Student artifacts provided multiple examples of this incremental progress. Their sentences for "photosynthesis" included:

"Plants use photosynthesis for sunlight." (not quite right)

"Plants use photosynthesis to make food." (a simple definition)

> "Hey, now that I think about it, when machines are solar powered, it is pretty much photosynthesis." (a complete thought, and an example of creative thinking about the concept)

Students' sentences for "autotroph" continued this demonstration of incremental growth.

> "Plants are autotrophs." (a simple definition that does not demonstrate concept knowledge)
>
> "The plant is an autotroph because it uses carbon dioxide and water with sunlight to make sugar and oxygen." (a more complete definition)
>
> "If I were a autotroph I would never be hungry." (creative use of the concept, demonstrating mature understanding and ownership).

While "photosynthesis" and "autotroph" are highly specialized science words, "host" has meanings in other contexts as well. Learning the concept of "host" in science is thus a different task, requiring discrimination among multiple meanings and choosing the meaning for science. The first three student sentences below are simple definitions that do not necessarily demonstrate science concept knowledge.

> "A dog is a host for fleas."
>
> "He was the host of the virus."
>
> "I'm a host. All people and animals are hosts."

The next student sentence comes closer to demonstrating concept knowledge,

> "I am a host. Viruses use me for energy"

and the final student sentence,

> "A virus or bacteria needs a host in order to grow and develop"

provides more complete evidence of concept knowledge.

Ann's acceptance of incremental, partially correct sentences as evidence of progress allowed her to provide invaluable support to her students. Her definition activities scaffolded incremental growth in knowledge of science language, and she incorporated that language into class discussions and inquiry activities by capitalizing on informal knowledge. She used students' questions as levers for new learning and urged students to use writing as a tool to demonstrate understanding of science concepts. By accepting students' "novel applications of knowledge" (Taylor et al., 2016, p. 13) and allowing a range of acceptable answers she brought authenticity to learning tasks, engaging students in the construction of science concept knowledge.

Part 3: Implications for Practice

Opportunities for learning are "most profound when teachers can employ the very same inquiry processes for their own professional learning that they aspire to enact with their students" (Pearson et al., 2010, p. 462). Ann's own inquiry process helped set the stage for the scaffolding, modeling, and guided practice she offered her students. Although she did not characterize her approach using language of the GRR, descriptions of her planning process demonstrate incremental steps, scaffolding, modeling, and gradually releasing control to students.

> When I plan a lesson, I break down the parts to define it better for myself, so I know I have thought through what needs to be considered so my students will be successful. I am always considering how I can make a lesson more inclusive to all of my students. I consider who needs writing help, who needs copies of information, who will need adjusted assignments … I'm a teacher who continually looks at something and says, "Okay, I need to monitor and adjust because this isn't working and I need to break it down into smaller parts." So, even though I had lesson plans done for this upcoming

> week where we start our new unit, I adjusted several of them ... I was at school all day Saturday thinking about my journal and doing my lesson plans. I want to break it down and think through the process that it takes to make sure my students all get it but also are very comfortable and successful with getting it. We're going to start tomorrow by talking about making observations as a scientist and … where I thought I was going to do a short activity followed by a PowerPoint, after I know my students I need to take a little more time tomorrow to have them digest this piece before I expect them to do it on their own.

Ann described a lesson that included explicit scaffolds, introduced and elaborated over several weeks of inquiry activities.

> I had modeled and assessed formatively the scientific method process in two earlier labs this quarter, so my students had previous knowledge for constructing labs in small groups. That built support for success for everyone. Students were given examples of how to write out each part of their scientific method process with sentence starters I provided for … interpretation and conclusion to improve their success with writing out results. Each student was to set up a controlled experiment planting seeds for a two-week period. Students could set up their lab any way they wanted within the scientific method. Everyone was successful in completing this lab. Many of them found that their plants did not grow and [they] evaluated their results well, recognizing flaws in their experiment. They reflected on changing if they have another chance to do it again. This lab provided individual success …. it was also lots of fun.

Here, Ann described the work she had guided students through previously to prepare them for conducting inquiry on their own. She details the scaffolds she incorporated into this inquiry: examples for how to write each part, and sentence starters for particular sections.

Students then set up their own inquiry, observed the results, and evaluated the outcomes. Thus, Ann edged students through the "Shared Responsibility" segment of Figure 1.9 and into the realm of "Student Responsibility".

Conclusions

By making her own learning the object of inquiry, Ann was able to "simultaneously develop the insights and pedagogical strategies [needed] to mentor ... students. (Pearson et al., 2010, p. 462) By infusing the GRR into her planning and instruction, she created learning experiences that insured student success, even if only at incremental levels. Perhaps without even realizing it, Ann utilized all elements of the GRR to develop her students' knowledge of the language of science, connect that language to science concepts through formal and informal activities, and promote her students' independent use of science knowledge.

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Table 1.

Pre/Post Assessment Example for Vocabulary Term: **Habitat** and Scores for Each Response

Item	Scoring
Circle the letter of one answer.	
1. How well do you know this word?	
a. I've never heard this word before	0
b. I've heard this word, but I don't know what it means	1
c. I think I know what this word means, or what it is related to	2
d. I know this word and can use it correctly	3
If you chose answer "a" from question #1, please go on to the next word.	
If you chose, b, c, or d, from question #1, then continue.	
2. I think the word may have something to do with:	
a. a person	0
b. organizing	0
c. environment	1
d. food	0
3. I think this word means:	
a. the way the sun warms the Earth	0
b. a natural home of an animal, plant, organism	1
c. gathering food	0
d. placing things in order	0
4. **Write a sentence using this word:**	0, 1, or 2