Building Science Language

Principles for integrating science and vocabulary instruction

By Sara Nelson and Patti Allen

Science is a great time to focus on language development in the elementary classroom. Participation in science requires that students use language to present claims, engage in argumentation, and partake in science and engineering process skills. Over the years, we have noted the importance of vocabulary in our students' ability to participate in the language of science. Research also notes a clear link between children's early experiences, including exposure to rich vocabulary, and academic success (Duncan et al. 2007). We decided to examine ways to effectively integrate vocabulary instruction in science and set out to develop a list of core principles to help guide this cross-curricular integration. Our goal was to support student vocabulary development, which in turn would support the development of science language and the ability of all students to fully participate in science.

PRINCIPLES OF VOCABULARY DEVELOPMENT IN SCIENCE

Vocabulary is generally defined as knowledge of words and word meanings. Studies have shown that vocabulary is a significant predictor of overall reading comprehension and student performance (Fisher and Frey 2014). In essence, it is at the core of reading, writing, speaking, and listening in all subject areas. Vocabulary plays a crucial role in science because it is at the heart of science learning and knowledge building. To discuss and build knowledge, students need to have access to the vocabulary of science. Therefore, we felt it is critical to develop research-based principles for teaching vocabulary in science. We share our thoughts in the following paragraphs as well as a few core references.

Principle One: Concrete Experiences First. Vocabulary instruction should follow and be anchored in concrete science experiences whenever possible. This principle builds off research presented by Olson (2008) about the importance of grounding science instruction in concrete science experiences before introducing abstract representations such as science text (vocabulary). Olson's article highlights the need for elementary science teachers to give students something concrete to connect vocabulary to in their developing understandings. Suárez, Bell, McCulloch, and Starr (2020) also discuss the need for science educators to focus on students developing conceptual meaning first instead of pre-teaching vocabulary.

Principle Two: Use and Present Terms in a Variety of Ways. Vocabulary instruction should introduce terms through multiple modes and use the terms across multiple experiences. For example, one unit of study might work with vocabulary through word walls, journal writing, drama, daily discussions, or student concept maps. Repetition and multiple exposures to vocabulary is important. Stahl (2005) cautioned against "mere repetition or drill of the word," emphasizing that vocabulary instruction should provide students with opportunities to encounter words repeatedly and in a variety of contexts.

Sampling of Connections to Common Core State Standards: English Language Arts

Kindergarten Vocabulary Acquisition and Use: CCSS.ELA-LITERACY.L.K.4	Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on kindergarten reading and content.
Third Grade Vocabulary Acquisition and Use: CCSS.ELA-LITERACY.L.3.4	Determine or clarify the meaning of unknown and multiple-meaning word and phrases based on grade 3 reading and content, choosing flexibly from a range of strategies.
Fifth Grade Vocabulary Acquisition and Use: CCSS.ELA-LITERACY.L.5.4	Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 5 reading and content, choosing flexibly from a range of strategies.

Principle Three: Science Content and Science Process Vocabulary Are Equally Important. Recent articles about content literacy versus disciplinary literacy have encouraged consideration of the role both science process vocabulary and science content vocabulary play in the development of overall science vocabulary (Grysko and Zygouris-Coe 2020). What process words, such as *observe*, will my students need to understand to assist them in developing science process knowledge or the specialized language of science? Additional process words might include develop, interpret, analyze, design, and construct. And what content words, such as *adaptation* or *natural selection*, will my students need to understand to assist them in developing science content knowledge? Content words will vary by unit but should be tied to the disciplinary core ideas.
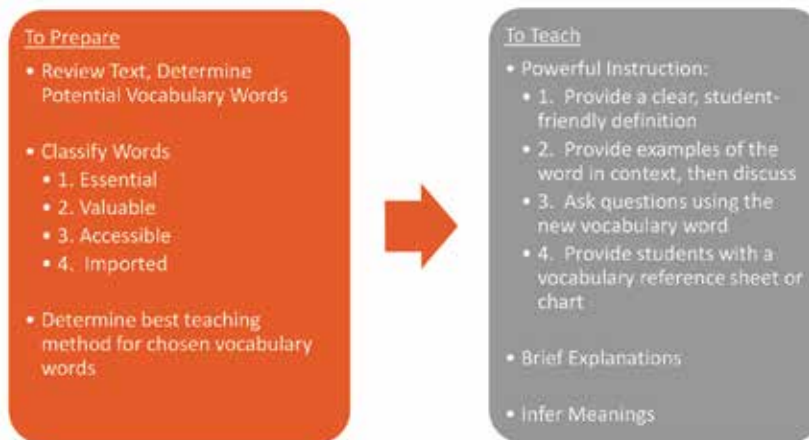
Principle Four: Be Deliberate Yet Flexible in Vocabulary Instruction. It is important to prepare for vocabulary instruction in science. However, you may find during a course of study that new words for instruction will suddenly present themselves. Create and use a flexible framework for vocabulary development in science. This will help you respond to student needs and keep you focused on their learning.

THE PRINCIPLES IN ACTION IN THE SCIENCE CLASSROOM

Prior to the start of any unit of study, consider what terms may be good to focus on for the science unit of study. Create a flexible list that can be revised throughout your course of study. Be sure to consider both science process words and science content words that students may need support in learning. Then, determine the best method for your class to organize new vocabulary. Ideas might include a word wall, vocabulary journal page, or concept map.

FIGURE 1

Overview of the SWIT approach

To Prepare
- Review Text, Determine Potential Vocabulary Words

- Classify Words
  - 1. Essential
  - 2. Valuable
  - 3. Accessible
  - 4. Imported

- Determine best teaching method for chosen vocabulary words

To Teach
- Powerful Instruction:
  - 1. Provide a clear, student-friendly definition
  - 2. Provide examples of the word in context, then discuss
  - 3. Ask questions using the new vocabulary word
  - 4. Provide students with a vocabulary reference sheet or chart

- Brief Explanations

- Infer Meanings

As you begin the unit of study, listen to the words students are using as they share their prior knowledge. Ask for clarification if you are unsure of a student's personal meaning. We encourage teachers to value and leverage students' communication when observing and making sense of phenomena (Suárez, Bell, McCulloch, and Starr 2020). To access prior knowledge and class vocabulary, we have found it helpful to show a picture or some type of visual phenomena to promote rich conversations that uncover vocabulary. Recording beginning vocabulary on a graphic organizer or observation notes for later reference. These notes can be used to guide vocabulary instruction throughout the unit and document growth.

During the unit of study, focus on introducing or reviewing science process vocabulary at optimal times. Prior to student investigations can be a great time to introduce process vocabulary, while after investigations or experiments might be the optimal time to introduce content vocabulary. Throughout the unit, push students to share details about their understandings of vocabulary words. As the unit of study progresses, use key vocabulary words in a variety of contexts and modes. For example, define words through drama, illustrations, journal writing, class discussions, or concept sorts.

At the conclusion of your unit of study, ask students to use and/or define selected vocabulary in the chosen summative assessment. This will allow you to reflect on how well students learned the vocabulary and if you might need to make any changes to your practice. Do a final review of any vocabulary data collected throughout the unit and make notes to assist future teaching. We have found it helpful to do this right away—before time gets away from you!

THE PRINCIPLES APPLIED TO SCIENCE TEXTS

Another key element in the development of science vocabulary is text. Typically, there are two uses of text in the elementary science classroom. The first is to engage and encourage students to access their prior knowledge on a specific science concept. The second is to use text to clarify concepts after a science investigation or experiment. To select vocabulary words from

texts, we have found a strategy called Selecting Words in Text (SWIT) from Graves et al. (2009) to be helpful. The SWIT approach deals with four types of words: Essential Words, Valuable Words, Accessible Words, and Imported Words. An overview of the approach can be found in Figure 1.

Essential Words are important for understanding the text. An Essential Word may appear only once or repeatedly in the text. However, without an understanding of that word, students are unable to grasp the meaning of the text. Valuable Words have general utility for students' reading and writing. The age of the students will matter for this category. This is because what might be valuable to a second grader may not be for a sixth grader. Accessible Words are more common or higher frequency words that are not likely to be understood by students who have limited vocabulary knowledge. By covering Accessible Words, vocabulary gaps can be addressed. Graves et al. (2009) share that an example might be the words *consider* and *recent* for fourth graders with limited vocabulary. Last, Imported Words enhance a reader's understanding, appreciation, or learning from a text but are not included in it.

Let's look at an example. In the book *How to Become an Accidental Genius* by Elizabeth MacLeod and Frieda Wishinsky (2019), there is a short biography on Mary Sherman Morgan (p. 66). The text shares how Mary invented the fuel Hydyne. This fuel helped power the Jupiter-C rocket that put Explorer I, the first American satellite, into orbit. She became known as "The Woman Who Saved the U.S. Space Race." This text could be used for showcasing application of science concepts, diverse role models in science, and also career opportunities. The steps for applying the SWIT approach to this text are shared in Table 1. We encourage teachers to use this approach before using a text with students.

CONCLUSION

"In summary, active vocabulary instruction should permeate a classroom and contain rich and interesting information. Vocabulary instruction should cover many words that have been skillfully and carefully chosen to reduce vocabulary gaps and improve students' abilities to apply word knowledge to the task of comprehension." (Butler et al. 2010)

We like the way this quote expresses and sums up the need for active vocabulary teaching. In particular, we love the word *permeate*. Vocabulary instruction should permeate every aspect of the elementary science classroom. This is so that all students have the opportunity to develop and participate in the language of science. Having access to experiences that build science language is important. Therefore, we felt it was important to develop a set of vocabulary principles to help us guide vocabulary instruction that advances students' understandings in science.

TABLE 1

Applying the SWIT approach.

Step 1: Create a list of unfamiliar words that you would like to cover from the chosen text.	Possible words to include from the text: persisted, manufacture, explosives, aviation, propel, Russia, fuel, Hydyne, Jupiter-C rocket, satellite, patents
Step 2: Review and identify words from the list that fit into the four categories and narrow the list down.	Essential: fuel Valuable: Hydyne, Jupiter-C rockets, aviation, Russia, patents Accessible: propel, manufacture, explosives, persisted Imported: NASA, civil rights, women's rights
Step 3: Determine the best instructional approach (Baumann et al. 2009–2013; Beck et al. 2013).	Powerful Instruction: The teacher (1) provides a clear definition, (2) provides and discuss context, (3) asks questions about the word and (4) provides a vocabulary reference sheet. Brief Explanation: When the word is encountered, the teacher stops briefly and provides a synonym or short definition and a context sentence. Infer Meaning: Teacher encourages students to infer meaning for words with useful context or easily identifiable word parts.
Step 4: Implement the vocabulary instruction.	Pick a method from step 3. Additionally, strive to provide opportunities for students see, use, and review the words repeatedly.

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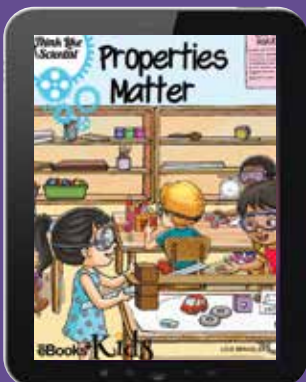
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