As explained in A Framework for K–12 Science Education, learners of science are also language learners, and the language of science is critical to both learning and communicating science concepts. Such concepts include students’ interactions with both science content and practices: “As such, every science or engineering lesson is in part a language lesson, particularly reading and producing the genres of texts that are intrinsic to science and engineering” (NRC 2012, p. 76). Teachers play a critical role structuring students’ exposure to language in the science classroom, as well as science in the language classroom, as they support students’ learning to communicate science content and practices through classroom investigations and sense-making discourse.

The emphasis on reading and literacy in elementary schools often prioritizes reading over, or even instead of, science. Literacy instruction is typically delivered separate from students’ science instruction, but such practices misrepresent the natural blend of science and language learning in our lives both in and out of the classroom. Neurological research reinforces first providing students with experiences that build a base for future learning. Cognitive researchers have shown that “language is learned through multiple interactive experiences involving vocabulary and grammar” (Caine and Caine 1999, p. 69), yet recent moves toward knowledge-based literacy curricula have led to science being “covered” by reading about science topics. Spatial memo-
ries are built on experiential learning and social interactions (Vygotsky 1978), and such active learning supports learning science and academic language. With policies that strongly emphasize reading, teachers need interdisciplinary strategies that not only represent professional scientists’ practices but also support students’ engagement and learning in both science and reading. Opportunities abound for teachers to help students recognize the fluid connections between disciplines such as science, reading, social studies, and mathematics as complementary components of everyday life. In this article we present practices that support both reading and science instruction, building learning across subject areas.

**Discourse and Argumentation**

Scientists and engineers use discourse practices that are foundational to critical thinking. Beginning in early grades, science instruction can help students learn to present claims supported by evidence. These practices simultaneously address reading, writing, language, speaking, and listening standards emphasized by the Common Core State Standards for English Language Arts and similar state-adopted standards and become tools for deep science and language learning.

Student discourse in a science classroom includes argumentation, and it is important to help students contrast the science meaning of argumentation with the common use of the word, which usually implies anger or negative feelings. Argumentation in science instead provides students with opportunities to experience reasoning and exchange ideas. Developing a classroom culture that facilitates rich classroom discourse through argumentation requires a shift in typical classroom practices for both teachers and students. When teachers consistently encourage students to elaborate on and justify their thinking with evidence, students can develop a greater understanding of science and science practices. Such classroom discourse supports standards and objectives for both science and literacy.

**Practices, Crosscutting Concepts, and Interdisciplinary Connections**

Providing students with language that supports communication is embedded throughout the Next Generation Science Standards (NGSS Lead States 2013). The three-dimensional model of NGSS includes the disciplinary core ideas (DCI) of science, crosscutting concepts (CCC), and science and engineering practices (SEP). There are many practices that are common in both science and literacy. For example, in addition to students using evidence to support claims, both science and reading practices may also include students asking questions, constructing explanations, obtaining, evaluating, and communicating information, interpreting and using procedures, and sequencing events.

Within the science disciplines (life, physical, and Earth/space science), students have opportunities to engage in CCC that also support language development, such as cause and effect, structure and function, patterns, and systems and models. The applications in this article blend language and science and provide opportunities for students to engage in each of the dimensions of NGSS.

**Touch, Talk, Text**

Traditional approaches to science instruction often include reading science text, some hands-on science experiences, and teaching science language in isolation. We propose instead that elementary teachers integrate touch, talk, and text in their science instruction to support authentic scientific inquiry and disciplinary literacy for elementary students.

**Touch**

It is important to launch science instruction with students’ hands-on/minds-on experiences. Whether students are examining rocks, observing and measuring plant growth, or rolling cars down ramps, such investigations provide students with the context for learning, build a base for connecting experiences with language, and the experiences provide evidence students can use to support their claims.

**Talk**

When teachers start with science activities and facilitate student discussions, they provide opportunities for students’ authentic use of scientific vocabulary, syntax, and discourse patterns. Rather than beginning a lesson by presenting words and definitions out of context, students’ learning language as they engage in activities encourages discourse patterns that support students’ communication and solidify their learning of science language and content. As the teacher engages in science investigations with students, it is important to verbalize science practices using vocabulary that supports students’ rich engagement in word meanings. For example, “Our butterfly has emerged from its chrysalis, the pupal stage of metamorphosis.” Teachers can help students understand word meaning by
breaking down the word into its parts. “Metamorphosis is the word that describes a big (meta-) change (morph) from egg, larva, pupa, to adult process (-osis).” Written labels for objects during activities deepens students’ connections between verbal and written words and their meanings. For less-concrete words or phenomena that cannot be directly observed, pictures, symbols, and text visuals provide a tangible reference for social learning and shared discussion.

Teachers can foster students’ language development by asking guiding questions and supporting students to take up scientific discussion. Launch an experience with authentic, open-ended questions (“What do you predict will happen to the sound when we add more water to the glass?” “How do vibrations contribute to the sound?”) and intentionally question students during exploration (“How has the mealworm changed since our last observation?” “What is the next stage in metamorphosis?”). Then teachers can support students’ use and understanding of complex syntax to answer questions and engage in discourse with sentence frames. Simple frames can help students express complex ideas, such as:

- cause and effect (Because we added _____, the solution _____),
- predictions (I predict _____ because I’ve noticed the _____ pattern),
- argumentation (I (agree/disagree) with _____, because my evidence shows _____), and
- explanations (I know _____ is an (acid/base), because I observed _____).

Teachers can model this language, display the sentence frames, support students’ work with their partners to practice scientific discussions, and use the frames to structure students’ writing.

**Text**

It is important to identify informational texts that match your teaching objectives and represent high-quality science literature with features of scientific communication. Consider the source and accuracy of the information, current application to your classroom learning objectives, precision of language, and the inclusion of features of scientific texts (e.g., diagrams, tables, figures, close-ups, glossaries).

When students collect and record their own data, such as plant measurements or temperature patterns, they may communicate their data on a poster, through digital slides, or orally to peers. When students practice writing summaries using their own data, it provides a sense of ownership because students have the touch experience upon which to connect meaning.

Thoughtful use of graphic organizers can help students make linguistic and conceptual connections between ideas. For example, Venn diagrams can represent cause and effect, and concept webs or semantic maps can represent properties of an object or organism such as “Solids” or “Mammals.” Teachers can model using these organizers, display charts with key ideas, and have students complete their own graphic organizers. ReadWriteThink.org includes a variety of graphic organizer resources appropriate for elementary classrooms.

**Touch, Talk, Text in Action**

The following example offers starting points for teachers to implement touch, talk, and text.

**Life Science: Ecosystems, 3–5.**

**NGSS Connections: 3-LS3-1, 3-LS4-3, 3-LS4-4, 4-LS1-1, 5-LS1-1, 5-LS2-1**

**Touch:** Students build EcoColumns of terrariums and aquariums using two-liter soda bottles to study plants and animals (see Online Resources; Figure 1). Daily observations and data collections allow students to actively engage in problem solving related to needs of living things and making sense of the systems and patterns in the EcoColumns. Such activities contribute to evidence-based discussions. (Students must wear safety goggles during observations and use caution when handling the EcoColumns.)

**FIGURE 1**

**EcoColumn materials.**

- Two 2-liter bottles
- Rubber band
- Nylon mesh or screen (2 in²)
- Clear packing tape
- Terrarium:
  - Soil
  - 2–4 types of quick-growing seeds (rye, mustard, alfalfa)
  - 2–3 herbivore insects (crickets)
  - 2–3 decomposers (isopods)
- Aquarium:
  - Aquarium rocks
  - Durable freshwater plants (*Elodea*)
  - Algae
  - 2–3 small herbivore fish (mosquito fish)
  - 2–3 decomposers (freshwater snails)

Living organisms can be ordered from: Carolina Biological [https://www.carolina.com/living-organisms/10476.ct?intid=hom_l_nav_10476][1]

Note: Use caution when handling live animals, and students must receive school-provided parent approval before observing live animals.
FIGURE 2

Touch, Talk, Text examples.

**Earth Science: Rocks and Soil, K–3**
**NGSS Connections:** K-LS1-1, K-ESS2-2, 2-LS2-1, 2-ESS1-1, 3-LS4-1
**Touch:** Students observe patterns, textures, size, and scale while exploring rocks and soil.
**Talk:** Building on student experiences with rocks and soils, they are positioned with language to guide their student-to-student discourse. Provide and frequently reference a chart or word bank with visuals for students to use precise vocabulary in peer discussions. Examples of key questions include: Describe what your rocks have in common and how are they different? What occurs to make rocks look and feel different? What is the role of rocks in plant and animal survival? Provide one example of the role of water in weathering of rocks. How can we design an investigation to determine if plants need soil to survive? What is the relationship between plants and soil? What evidence can you provide to support the role of soil based on the form and function of plant roots, stems, and leaves? What evidence can you share with your partner to explain what happens to things in the soil that were once living?


**Physical Science: Forces, 3–5**
**NGSS Connections:** 3-PS2-(1-4), 4-PS3-(1-4), 5-PS1-(1-4), 5-PS-2-1, 5-PS3-1
**Touch:** Students are actively engaged in problem solving through investigations: Friction, Electricity and Magnetism.
**Talk:** Building on students’ experiences with cars and ramps, magnets, or electric circuits, students now have experiences to discuss their experiences with unseen forces. Label objects and narrate phenomena during exploration to provide students a model of language use before questioning. What causes an object to move? What is the evidence that forces result in motion? In what ways can friction be useful in our everyday lives? Are there ways that we can see energy transfer occur? What happens if... (open-inquiry opportunities)? What caused... to happen? Have students discuss with a partner before sharing their explanations with the class, or rehearse and record explanations in short video clips.

**Text:** A TRUE Book: Friction, pp. 8, 21, 23, 24–25; A TRUE Book: Electricity and Magnetism, pp. 12, 13, 16, 21, 29, 3; A TRUE Book: Energy, pp. 7, 8, 10-11, 38
Talk: Building on student observations, guide student talk by posing questions for small-group discussions. Have students take turns answering the following questions with two to three peers so each student has the opportunity to talk about the phenomenon: How do seeds begin to grow when they are planted under the surface of the soil? What is the essential role of plants in all ecosystems? What are biotic and abiotic factors, and what are each in our terrariums and aquariums? In what ways do plants and animals depend on one another? What is the role of decomposers in our terrariums and aquariums? How does the soil contribute to biotic and abiotic factors in our terrarium? How do we describe energy transfer when an herbivore (consumer) in our terrarium or aquarium eats a producer? Provide sentence frames to support students’ use of precise vocabulary and complex syntax, such as “When seeds are planted under the surface of the soil, they begin to grow by ___” and “Plants depend on animals for ___,” and animals depend on plants for ___.” Conclude with an opportunity for each group to share what they talked about and facilitate a whole-class discussion to connect their ideas.

Text: Students connect their EcoColumn experience and observations and their discussions to a quality children’s book on the topic, such as: A TRUE Book: Plants and Ecosystems (Kurzius 2019; pp. 8, 12, 16, 17, 25, 26, 41).

This example is one model of how students experience and learn through observations and discussions about energy transfer and interactions within an ecosystem and then connect with the concepts in a science text. The teacher and students can participate in rich text engagement through whole-class, small-group, and partner read-alouds from A TRUE Book: Plants and Ecosystems and other texts. Beginning with touch, students’ active engagement provides an experiential base that motivates their learning content and connecting with the practices of science. Students’ ownership of the terrariums and aquariums that they built stimulates their desire to further their learning. As they share their experiences through talk with their peers and the teacher, they participate in the sense-making of science. The text component of this example, A TRUE Book: Plants and Ecosystems, creates opportunities for connecting the text content to their daily observations and classroom discourse about the terrariums and aquariums.

To provide each student with their own copy of the text, teachers (within copyright guidelines) can provide photocopies of the necessary pages for that day, allowing students to highlight the rich vocabulary and engage with the text so they can refer to their notes and questions throughout discussions and argumentation. Students can use text-based evidence and vocabulary from the book in combination with data and evidence from science observations and activities to make sense of the concepts. When we launch science learning with students’ active engagement and add discourse combined with connecting to rich text, we ensure students’ cognitive, affective, and kinesthetic learning.

Figure 2 provides additional examples for teachers and students to engage in touch, talk, and text in the science classroom. Too often, science and reading are taught separately, but literacy practices can be integrated into inquiry-based, science activities. Even when reading and writing practices are intertwined with hands-on science exploration, teachers may miss valuable opportunities for students to ask questions, discuss their findings, and participate in argumentation. Once students become practiced in the structure of science text and using content-specific vocabulary, student-to-student discourse becomes a natural part of the science classroom culture. With increased exposure to discourse, students and teachers will find excitement in building science background as they develop a deeper science understanding. ●

REFERENCES

ONLINE RESOURCES

PRINT RESOURCES

Sarah J. Carrier (sarah_carrier@ncsu.edu) is a professor of science education, Jill F. Grifenhagen is an assistant professor of literacy education, and Danielle R. Scharen is a doctoral student of science education, all at North Carolina State University in Raleigh, North Carolina, and all are former elementary school teachers.