A Noteworthy Connection

Developing science knowledge and literacy with science notebooks

By Melanie Schneider, Jessica Bonjour, and Anna M. Bishop Courtier

In a second-grade class, students sort pictures into three states of matter: solids, liquids, and gases. Afterward, the teacher takes out a clear container filled halfway with water, a plastic cup, and a paper towel and asks students to identify the state of matter of each material. Students identify solids and a liquid but not gases. The teacher proceeds to stuff the paper towel in the bottom of the cup, then asks: What will happen to the paper towel when you turn the cup upside-down and push it into the water? After making predictions with partners, students jot their predictions down in their science notebooks. (Safety note: When working with fluids, remind students to notify an adult of any spills immediately to avoid slipping hazards.)

What can science notebooks tell us about student learning in the elementary grades? Rather than focus on a specific content lesson, this article focuses on K–3 learners and what science notebooks can reveal about science inquiry learning, the practices of "doing" science, and the development of academic language and literacy. We briefly describe the connections between science notebooks and science inquiry, the nature of academic language, and present an illustrative rubric to formatively assess academic language and literacy development in science notebooks. Three tenets guided our approach:

- The *NGSS* scientific and engineering practices (K–5) can guide science investigations in elementary classrooms (Pratt 2013);
- science notebooks do not only advance science knowledge but academic language and literacy development as well; and
- science notebooks provide a vehicle for ongoing, formative assessment of student learning that informs teaching.

SCIENCE NOTEBOOKS AND SCIENCE INQUIRY

Science notebooks allow students to record their inquiry journeys: questions, predictions, drawings, procedures, observations, data, conclusions, and reflections and wonderings (Fulton and Campbell 2014, p. 2). Science notebooks reveal students' observations and thinking about an investigation. As Fulton and Campbell (2014, p. 3) state, science notebooks are used throughout an entire investigation: at the beginning to record thinking or planning; during the investigation to record observations in words, numbers, or pictures; and afterward to help clarify thinking and share conclusions with others. Composition books, spiral notebooks, lined paper stapled together, and digital entries all serve well as science notebooks.

Because science notebooks are used throughout the science inquiry process, it is important to understand what science inquiry is. Colburn (2000, p. 42). describes inquiry as engagement in "essentially open-ended, student-centered, hands-on activities" and distinguishes between *structured*, *guided*, and *open inquiry*. These types of inquiry are differentiated by how much of the process is teacher-provided versus student-discovered

TABLE 1

Type of inquiry and related characteristics.

TYPE OF INQUIRY	QUESTION/ PROBLEM	MATERIALS	PROCEDURE	OUTCOMES
Structured	Teacher-provided	Teacher-provided	Teacher-provided	Student-discovered
Guided	Teacher-provided	Teacher-provided	Student-discovered	Student-discovered
Open	Student-discovered	Teacher-provided	Student-discovered	Student-discovered

(see Table 1, where student-discovered processes are highlighted). Although *open* inquiry is most closely associated with "doing real science," starting with *structured* inquiry and progressing to *guided* inquiry is often developmentally more appropriate for younger learners.

The *NGSS* science and engineering practices (SEPs) can be used to guide science inquiry across grade levels (Pratt 2013). Because of our interest in linking science notebooks to literacy development, we focus on three *NGSS* practices: Asking Questions, Planning and Carrying Out Investigations, and Constructing Explanations.

THE ROLE OF ACADEMIC LANGUAGE

Academic language is required for success in school. Learning academic language goes beyond knowing individual words to knowing and using language at higher levels. The WIDA Consortium (2009) describes academic language at three levels: *word*, *sentence*, and *discourse*. The *word level* includes knowledge of general academic and content-specific vocabulary. The *sentence level* includes knowledge of verb tense and sentence structure, including different types of sentences, prepositional phrases, and other post-noun modifiers that make sentences more complex. Finally, the *discourse level* describes the structure and organization of a text and "cohesive devices" (such as pronouns, word repetition, and synonyms) that refer back to people, objects, or ideas in a text.

USING A RUBRIC TO FORMATIVELY ASSESS SCIENCE NOTEBOOKS

Because children in grades K–3 are often unfamiliar with the complex vocabulary of science, science notebooks should focus on communicating meaning rather than on writing conventions. It makes sense, then, that assessment of science notebooks be formative rather than summative. For example, after modeling by the teacher and practice making notebook entries, students can self-assess their entries by completing a checklist about certain features of science notebooks (see Table 2).

TABLE 2

Student checklist for science notebooks.

QUESTIONS	YES	NO
1. Do I have a question?		
2. Do I have a prediction?		
3. Do I have a conclusion?		
4. Do I have an explanation?		

Teachers can assess science notebooks formatively by asking questions about important features of notebooks such as questions, predictions, observations and drawings, and conclusions and explanations. One way to do this is by creating a rubric with developmental stages for each feature. Our developmental stages involved looking at questions, predictions, and explanations (see Table 3, page 70). See the section "Constructing Explanations" for a description of the claim-evidence-reasoning framework.

Students may not reach the final stage for each feature, depending on the developmentally appropriate stage for the grade level and type of inquiry. With structured or guided inquiry, students cannot obtain stage 3 or 4 for questions, since the question is provided by the teacher. Teachers may modify or add rubric components such as observations, scientific drawings, and conclusions, again focusing on formative assessment of science notebooks for instructional purposes.

EXAMPLES OF STUDENT WORK

In the following excerpts from science notebooks, examples of the three SEPs are linked to academic language at different levels. Because of the students' young age, not every level of academic language is represented for each practice. The first example is conceptual. Small ramps and moving objects are used in the second example, and as a safety precaution, teachers should place them carefully to avoid tripping or projectile hazards in the classroom.

Asking Questions

In a grade 2–3 notebook entry (Figure 1, page 71), students posed a question about earthquakes and volcanoes. The student's question, "How do earthquakes and valcanos *[sic]* change the land?" was both understandable and well formed. The question is followed by two simple Stage 2 predictions ("I think a earthquakes shake the land. valcanos can exploed [explode] and case *[cause]* danger"). Several "I wonder" questions appear at the bottom of the page. Despite the spelling, this entry shows appropriate use of content-specific vocabulary terms such as *earthquake*, *volcano*, and *explode*. A possible sentence-level objective for academic language would be learning how to express a prediction with *will + verb*. Objectives for discourse-level academic language could include how to organize notebook entries by listing the date and topic at the top of an entry and labeling questions, predictions, and drawings. This objective relates to the *Common Core State Standard* (*CCSS*) for English Language Arts (CCSS.ELA-LITERACY.RI.2.5): Know and use various text features (e.g., captions, bold print subheadings, glossaries, indexes, electronic menus, icons) to locate key facts or information in a text efficiently. The bonus is that students can meet this standard experientially, by writing in their science notebooks, rather than by analyzing others' writing.

Planning and Carrying Out Investigations

In another grade 2–3 notebook entry (Figure 2), students explored the concepts of force and motion by creating two conditions for a ball to roll down a ramp. The different ramp heights (one book vs. two books in the drawing) show evidence of the student's planning. The drawing provides evidence for another *CCSS* standard (CCSS.ELA-LITERACY.RI.2.7): Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text. The entry also includes a more complex prediction (Stage 3) that includes a reason ("I think the taller one will go faster and they [the balls] will stay on [the ramp] because the rulers have two lines [grooves] on each side"). At the word level of academic language, the use of comparative adjectives (*-er*) can be introduced or reviewed. At the sentence level, students who have mastered simple sentence predictions can make the sentence more complex by using the word *because* to explain a reason.

Constructing Explanations

At the bottom of the notebook entry in Figure 2, the student confirms the prediction and offers a possible explanation for the observed outcome ("I was right and I thought that the taller one would go farther because it has more power"). Although only partially correct, the sentence clearly attempts to explain why the ball rolled farther on the taller ramp (Stage 3).

Constructing scientific explanations often involves a series of sentences that follow a claim, evidence, and reasoning framework (Zembal-Saul, McNeill, and Hershberger 2013). A *claim* is an answer to the

TABLE 3

Science notebook rubric with developmental stages.

CATEGORY	PRE-STAGE	STAGE 1	STAGE 2	STAGE 3	STAGE 4
Questions	No question	Teacher-provided yes/no question	Teacher-provided open-ended question	Student-developed yes/no question	Student-developed open-ended question
		Sentence level			
Predictions	No prediction	A few words or incomplete sentence; use of starter sentence or picture	A simple sentence (It will…)	1–2 simple sentences or a complex sentence (I think X will happen because…)	Complex sentence expressed as if-then statement (If X…, then Y… because…)
		Word level	Sentence level		
Explanations	No explanation	A simple claim expressed as a sentence	Claim + one piece of evidence	Claim + one statement of evidence + attempt at reasoning OR claim + complex evidence (≥ 2)	Claim + two or more statements of evidence + accurate reasoning
		Sentence level	Discourse level		

question posed at the beginning of the investigation (e.g., the ball went farther on the higher ramp). *Evidence* supports the claim based on observations or measurements (e.g., the ball on the taller ramp rolled farther than on the shorter ramp). *Reasoning* refers to the scientific principle or concept that explains why the evidence supports the claim (e.g., the potential energy of the ball is higher on the taller inclined plane, described as "power" by the student).

With teacher support, young learners can start with a claim and gradually add pieces of evidence to support it. When appropriate, reasoning can be built onto their explanations. Adding reasoning stretches students to think about science concepts and principles that help explain the outcome of an investigation (e.g., gravity and potential energy in the ramp example). Although we encourage adding reasoning to scientific explanations, providing a claim and supporting it with one or more pieces of evidence may be sufficiently challenging for young learners.

Let's briefly return to our initial example on states of matter. What happened to the paper towel when the upside-down cup was pushed into the water? It remained dry! This claim can be supported with evidence, but the real fun (and challenge) of constructing explanations is coming up with possible reasons why. In the process, students discover the role of the missing third state of matter in the investigation: air (a gas).

MAKING CONNECTIONS TO LITERACY

Certain features of science notebooks, including asking questions, making predictions, and using evidence to support a position, also figure prominently in other content areas, such as language arts. Teachers should ask questions such as "How are predictions the same when we are doing science and when we are reading a story?

FIGURE 1

Notebook entry #1.

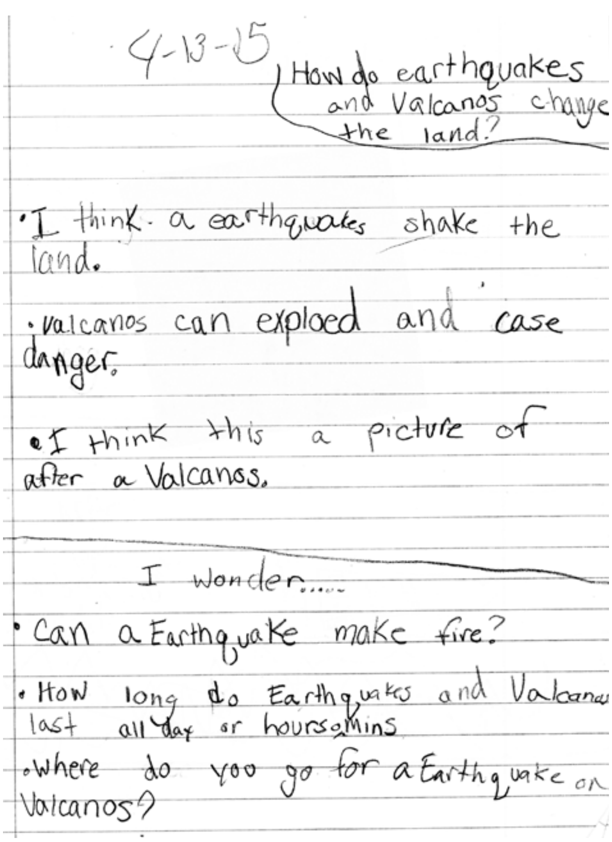
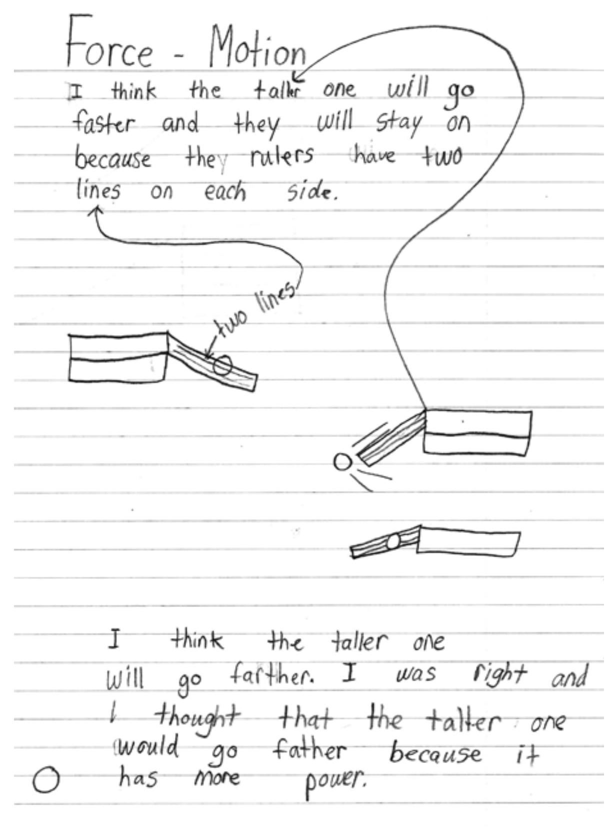


FIGURE 2

Notebook entry #2.



How are they different?" Children may respond by noting similarities and differences in grammar, content, or punctuation, or they may not know how to respond. The point is to get them thinking—and talking.

Using evidence to support claims can also be reinforced in both science and literacy contexts, whether reading stories or informational texts. When young learners are unsure of what *evidence* means, providing an example rather than an abstract explanation is more helpful. In the ramp example, teachers can ask a student to restate the claim (the ball went farther on the higher ramp) and then ask, "How do you know? What did you see, hear, touch, or measure?" The response (e.g., the ball on the ramp that was the tallest went farther) is the evidence. In language arts/reading, the first question, "How do you know?" also applies, but the evidence usually comes from the story or informational text itself. Using reasons as evidence is connected to another *CCSS* standard (CCSS.ELA-LITERACY.RI.2.8): Describe how reasons support specific points the author makes in a text.

In addition, science notebooks in K–3 classrooms can be used to differentiate instruction by embedding academic language goals for English language learners (ELLs) and bilingual learners in dual language contexts (where native speakers of English and another language are learning content together in two languages). Teachers who include explicit academic language goals at the word, sentence, and discourse levels in lessons that are connected to science topics promote both content and language learning. This is beneficial for all learners but essential for ELLs and other bilingual learners.

Another powerful strategy to develop academic language and expand vocabulary is to recognize cognates in two languages, which are commonly found in Spanish and English in science. Because many Spanish speakers learning in English (and English speakers learning in Spanish) do not notice cognates, teachers should strive to explicitly teach the many English-Spanish cognates in science (e.g., *volcano - volcano, explode - explotar, ramp - rampa*). Finally, formative assessment of science notebooks and the emphasis on communicating meaning over correctness can encourage ELLs and other bilingual learners to use new language structures and vocabulary in their science notebooks, which will contribute to fluency in writing.

CONCLUSION

Science notebooks offer young learners multiple opportunities for learning, practicing, and reflecting on science processes and concepts. Importantly, they provide an authentic context for reading and writing. Teachers can enhance literacy development by preparing students to use science notebooks regularly, rereading student notebook entries for formative assessment purposes, and encouraging students to self-assess their progress. Using science notebooks can thus serve dual purposes: to enrich inquiry learning and serve as a bridge from science to literacy development. ●

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