Book Links

CLASSROOM CONNECTIONS:
INQUIRING MINDS
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We know that we're supposed to be raising the bar and making science work more rigorous, and we know that the Common Core State Standards (CCSS) and the Next Generation Science Standards encourage more student inquiry. But how best to implement these directives?

One approach is to weave together the science skill set of observing, questioning, predicting, describing, explaining, arguing, and concluding with the literacy practices of reading, writing, speaking, and listening. The ideal result will be learners who are curious, ask measurable questions, and can form answers that derive from reasoning about evidence.

When we develop students' English language arts skills in critical thinking, cause-and-effect, hypothesis, prediction, analysis, and synthesis, we can map those skills to scientific thinking, and vice versa. For the many educators who feel comfortable using literature in the classroom but are timid about their science expertise, using books to build a bridge to science can yield impressive results for teaching and learning.

The National Science Education Standards defines scientific literacy as "the ability to predict, describe, and explain natural phenomena." Scientifically literate students are able to read about or experience science topics and then engage in scientific argumentation to reason whether or not the conclusions being discussed are valid. The Common Core State Standards emphasize this same process in an overview of the English language arts standards, which include, as students' goals, the ability to "assess the veracity of claims and the soundness of reasoning" and to "cite specific evidence when offering an oral or written interpretation . . . making their reasoning clear."

When teachers marry students' natural curiosity with cross-disciplinary thinking skills, they strengthen both content areas of science and English language arts. One way to promote scientific literacy in upper-elementary classrooms is to take a student-centered inquiry approach. While traditional science instruction gives students a prescripted set of procedural steps to follow, an inquiry-based approach gives students a thinking process that can be applied to many scientific challenges; it is a transferable mind-set.

Students can begin by gathering information to answer science questions using their senses—seeing, hearing, touching, tasting, and smelling. (This approach is detailed in the essay "Learning Science through Inquiry," by Christine Collier and others, posted on the Annenberg Learner website. Visit the "Web Connections" on www.booklistonline.com for a link to the document.) This strategy encourages students to think like a scientist, conducting research and making sense of their learning through metacognition (thinking about their thinking). The inquiry process values prior knowledge and encourages multiple solutions for every problem. Books are not simply reference materials; they are springboards to new investigations and can be used to verify student-generated information. Following are several suggestions for encouraging inquiry in the upper-elementary classroom with books and related activities. Log on to www.booklistonline.com for an extended version of this article.

Build "Science Talk" Skills

Learning to speak, present, and listen effectively forms an important strand of the Common Core State Standards in the elementary and middle grades. Communication through "science talks" allows students space to talk with each other, exchange ideas, and collaborate in their attempt to understand scientific concepts. Science talks require students to use poetic, visual, analogical, and kinetic language to express their understandings of concepts, as Karen Gallas outlines in *Talking Their Way into Science: Hearing Children's Questions and Theories, Responding with Curricula* (1995). Ideally, during these discussions, a teacher's role is not as the authoritative dispenser of knowledge. Resisting the impulse to dominate a discussion may be more difficult than a teacher might anticipate. However, when educators relinquish control and allow uninterrupted collaborative discussion among students to occur, learners gain necessary space to work through their thinking.

In the Classroom

To encourage a science talk, you can begin by sharing Walter Wick's *A Drop of Water* (1997) and then conducting an experiment that examines what floats and what sinks in water. (You'll find experiment suggestions listed among the "Web Connections" for this article.) Then, initiate a science talk following this recent example, from an elementary classroom, in which the students are wondering why ice—made of water—floats on top of the water:

Teacher: The question is, "Why does ice float?"
Student 1: It's expanded, so it takes up more space in the water, which makes it float.
Student 2: We know that when water freezes, it becomes ice, and ice is lighter than water.
Student 1: We know that when ice warms up, it melts back into water and no longer floats.
Student 3: So frozen ice floats, and melted ice sinks. So ice floats because it is frozen.

In this science talk, the group was lucky to have a student with prior knowledge about the structure of ice. This student was able to posit a hypothesis on why the ice will float. That helped the conversation flow into the area of density. As the talk progressed, student 3 was able to combine the evidence that was presented by other students and come up with a conclusion: "Ice floats because it is frozen." It's clear that these students are in the beginning stages of critical thinking. They are comparing and contrasting, analyzing and breaking a whole into parts to discover their relationships, discriminating (distinguishing carefully between the structures of frozen ice and water), and reasoning logically (drawing a conclusion from the evidence). Note that the interplay of conclusions or arguments with evidence is, again, a skill directly called for in the Common Core's "Anchor Standards for Reading," number 8: "Delineate and evaluate the argument and specific claims in a text including the validity of the reasoning as well as the relevance and sufficiency of the evidence." Although the "Anchor Standards" ask students to call upon text, and in the above example, students draw upon visual observation, the required thinking skills are the same.

Notice that the teacher plays a minor role in the discussion: putting the question out there and only answering a direct question about the inquiry. Teachers familiar with the Junior Great Books model of "Shared Inquiry" or the "Socratic Seminar" methodology know how important it can be for a teacher to play the role of facilitator, teasing out students' knowledge while allowing students to take ownership of the conversation.

Be careful to avoid leading questions, which can give students clues as to the "correct" way to answer. Instead, make room for their thinking. You may wish to follow the *bansho* strategy of lesson study that we discussed in our book *Story Starters and Science Notebooking: Developing Student Thinking through Literacy and Inquiry* (2009). In this method, the teacher acts as the class recorder, writing student ideas on a white board or projecting them with a document camera, letting students have the fun of drawing the conclusions.

Following are suggested titles to support discussion during science talks.

Helpful Texts

Does This Make Sense? Constructing Explanations. By Barbara A. Somervill. 2007. 24p. illus. Rosen, lib. ed., $21.25 (9781404234857); paper, $8.25 (9781435826816); e-book, $21.25 (9781435841024). 025.5. Gr. 3–5.

As students near the end of their scientific research, they must study their findings and reach a conclusion, the process outlined in this title.

A Drop of Water. By Walter Wick. Illus. by the author. 1997. 40p. Scholastic, $19.99 (9780590221979). 546. Gr. 3–6.

Photographer Wick, best known as the illustrator of the I Spy picture-book series, uses simple techniques to show water properties such as surface tension, adhesion, capillary attraction, molecular motion, evaporation, and condensation. A fine, eye-catching introduction to a well-focused topic.

Sorting It Out: Evaluating Data. By Barbara A. Somervill. 2007. 24p. illus. Rosen, $22.60 (9781404234871); paper, $8.25 (9781435826823); e-book, $21.25 (9781608530878). 519.2. Gr. 3–5.

Doing the work of science is more than testing your ideas. In this book, students learn to sift and sort their data to identify patterns.

Super Smart Information Strategies: Put It All Together. By Phyllis Cornwall. 2010. 32p. illus. Cherry Lake, lib. ed., $19.95 (9781602796430); paper, $9.95 (9781610802628); e-book, $19.95 (9781602797734). 372.13028. Gr. 4–8.

Once research is completed, students learn how to shuffle their information, draw conclusions, consider the audience, and present findings.

Common Core Connections

- **CCSS.ELA-Literacy.SL.3.1–5.1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3–5 topics and texts, building on others' ideas and expressing their own clearly.
- **CCSS.ELA-Literacy.SL.3.4.** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

Who Is a Scientist?

For our students to develop the mind-set of a scientist, they need to move beyond cartoon exaggerations of who a scientist is. When early science learners are asked to draw a scientist, invariably they sketch white males wearing lab coats and glasses. Occasionally, they add the wiry hair of a "mad scientist." (Explore, for example, experiments conducted at Fermilab, in which students drew portraits of scientists, first based on prior knowledge and then again after meeting practicing scientists on a Fermilab tour: ed.fnal .gov/projects/scientists.) In our diverse nation, few students can identify with—much less thrill to—this image.

Incorporating biographies of scientists in the elementary classroom can help transform preconceptions (and misconceptions) of the scientist's image. Introducing young learners to the lives and work of the scientific community—past and present, famous and ordinary—is a great way to help students start to connect with scientific professionals—and perhaps envision themselves in a scientific field.

Biographies often tell the life story of a particular individual, either chronologically (showing which steps led to an eventual discovery) or through narrative expository (painting a picture of the scientist's life and personality). Teachers and students can generate inquiry questions for future classroom exploration from the context of these biographies. For example, a read-aloud of Tonya Bolden's *George Washington Carver* can introduce a unit on inventions, biotechnology, or the mind-set and patience of a long-term tinkerer. Biographies can also begin to develop a student's understanding of scientific discovery, anchor it in a historical period, and, while doing so, meet the CCSS standards.

In the Classroom

Reading biographies aloud should be an interactive process that can promote curiosity and inquiry if you follow these tips, adapted from L. Jamison Rog's *Early Literacy Instruction in Kindergarten* (2001):

- Plan an introduction. Find links to personal experiences that will encourage learners to also make connections during the reading.
- Set a purpose for listening. Consider "I wonder" statements, such as "I wonder if Jane Goodall always knew she wanted to study chimpanzees" or "I wonder if you need to study science in college in order to do field work about chimpanzees." Model your own curiosity, leaving room for students to do the same, recognizing that not all students will have prior knowledge about the scientist to share.
- Draw attention to illustrations and features of the text.
- Pause and revisit predictions, express curiosity, or comment on something interesting or how it relates to the student's own life. In *Reading with Meaning* (2002), Debbie Miller suggests signaling that you are shifting from reading aloud to sharing your own thoughts by laying the book in your lap. Don't forget to make space for student responses.
- Encourage questions, comments, and inferences. Ask students to reference the text to support their hypotheses.
- Connect to personal knowledge. A supporting question could be, "What did this story remind you of?"
- Compare texts. Ask students to connect and contrast key points across multiple biographies.
- Discuss reasons why the protagonist might have become a scientist. Ask students to justify their thinking with evidence from the text. For example, did the scientist show early leadership, perseverance in overcoming difficulties, patience, early curiosity, or propensity for finding answers? For students who need more structure to nudge their thinking, try this sentence prompt: "Being able to [ask students to fill in blank] helped [this person] to become a successful scientist." Students may have different perspectives on the same person.

Take care to be inclusive in selecting diverse biographies of scientists, and consider a breadth of subjects in order to maximize students drawn to science as an area of interest: biologists, zoologists, botanists, chemists, physicists, engineers, cosmetics concocters, industrial-product designers, paleontologists, museum educators, agricultural engineers, and more.

Helpful Texts

The following are excellent biographies to prompt discussion. Also, consider the titles in the award-winning Scientists in the Field series, published by Houghton Mifflin Harcourt, many of which are featured in the "Scientists at Work" feature on p.22.

George Washington Carver. By Tonya Bolden. 2008. 48p. illus. Abrams, $18.95 (9780810993662). 630.92. Gr. 3–6.

In this exemplary biography, the award-winning author provides both the requisite biographical details of the extraordinary scientist as well as the recurring themes of his career. Offering sourced quotations throughout, Bolden covers subtleties that simpler treatments tend to bypass, such as Carver's trepidation about leaving the mostly white Midwest to join Alabama's Tuskegee Institute.

Stone Girl, Bone Girl: The Story of Mary Anning. By Laurence Anholt. Illus. by Sheila Moxley. 1999. 32p. Frances Lincoln, paper, $7.95 (9781845077006). 560. K–Gr. 3.

This picture-book biography, illustrated with inventive artwork, personalizes the story of 12-year-old Mary Anning, of Dorset, England, who entered scientific history with her discovery of an ichthyosaur skeleton.

T-minus: The Race to the Moon. By Jim Ottaviani. Illus. by Zander Cannon. 2009. 128p. Simon & Schuster/ Paula Wiseman, $21.99 (9781416986829); paper, $14.99 (9781416949602). 741.5. Gr. 6–8.

Ottaviani and Cannon track the history of the American-Soviet race to the moon in this crisply illustrated graphic novel.

Temple Grandin: How the Girl Who Loved Cows Embraced Autism and Changed the World. By Sy Montgomery and Temple Grandin. 2012. 148p. illus. Houghton, $17.99 (9780547443157); e-book, $16.99 (9780547733937). 612. Gr. 4–8.

In this biography, students discover how Grandin used insights drawn from living with autism to imagine a new way to guide cattle more comfortably through farm routines. Blueprints and photographs help Grandin's ideas come alive for students.

The Watcher: Jane Goodall's Life with the Chimps. By Jeanette Winter. Illus. by the author. 2011. 48p. Random/ Schwartz & Wade, $17.99 (9780375867743); lib. ed., $20.99 (9780375967740). 590.92. Gr. 2–4.

This beautiful picture-book biography introduces students to Goodall's passions as a young girl and shows how they served the scientist well in her work as an adult researcher.

Common Core Connections

- **CCSS.ELA-Literacy.RI.3.3.** Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.
- **CCSS.ELA-Literacy.RI.4.1.** Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- **CCSS.ELA-Literacy.RI.5.2.** Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.
- **CCSS.ELA-Literacy.RI.5.9.** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

Create a Culture of Scientific Exploration

The Common Core State Standards call on students to be college and career ready, and one of the skills implicit in that readiness is the ability to work both independently and in teams to learn and innovate.

In the Classroom

Nurture a culture of scientific exploration by establishing a science corner or tinkering station in the classroom. This sets the tone that scientific inquiry is an essential part of your classroom culture. Consider adding the following materials to your tinkering station:

- **Observation tools:** magnifying glasses, binoculars, microscopes
- **Measurement tools:** thermometers, rulers, tape measures, scales, beakers
- **Documentation tools:** notebooks, digital cameras, sketch and graph paper
- **Animate and inanimate objects:** rocks, minerals, fossils, plaster casts, plants, terrariums, ant farms, bird feeders, pinecones, acorns, class pets
- **Electronics tinkering supplies:** magnets, a littleBits modular kit, or Squishy Circuits supplies to build safe circuits with homemade dough

These materials can be available for open inquiry or set out a few at a time with guided questions.

In a tinkering zone, also provide books and resources that spark students' imaginations while offering gentle scaffolding that encourages independent success. You want students to learn through doing, and physical tinkering lets them see concrete evidence of their learning. Supply "starter" books, such as the Helpful Texts listen below, that introduce concepts that can later be explored in more depth with additional resources or teacher support.

Consider adding a logbook where students can sketch and share their discoveries. Logbooks provide both useful documentation for teachers and a way for students to share cool discoveries with fellow classmates. Keep in mind that many students can better express inventions through drawings rather than through words, and having both mechanical pencils and colored pencils on hand will help students illustrate how objects have changed. With students, create and post a page of possible prompts that can quickly jump-start writing in their logbooks. Consider prompts with the word *because* in them, a low-pressure way to build students' habits in providing evidence to support assertions. This key concept in the Common Core State Standards develops naturally and authentically when students are doing hands-on tinkering.

Alternatively, set up a webcam or video camera on a tripod and post the above prompts nearby and let students record their thinking. Set aside a few moments at the end of the school day or week for a "Discovery Rewind," in which you share the students' videos with the class.

Helpful Texts

Arduino. By Terence O'Neill and Josh Williams. 2013. 32p. illus. Cherry Lake, lib. ed., $28.50 (9781624311376); paper, $9.95 (9781624312694); e-book, $28.50 (9781624313356). 629.8 Gr. 4–8.

This title introduces students to the low-cost microcontroller that, when plugged into a computer and loaded up with code that can be copied and pasted from the web, can make lights blink and sensors work. (You can buy an Arduino kit through parts suppliers such as Adafruit.com or Sparkfun.com.)

The LEGO Play Book. By Daniel Lipkowitz. 2013. 200p. illus. DK, $24.99 (9781465414120). 688.1. Gr. 1–up.

This heavily illustrated title will inspire students to think about repurposing their LEGO kits in new and creative ways while building their abilities to envision a product and construct an outcome.

What Are Insulators and Conductors? By Jessica Pegis. 2012. 32p. illus. Crabtree, lib. ed., $26.60 (9780778720782). 537.6. Gr. 3–6.

Pegis takes readers along on an exploration of the roles conductors and insulators play in the transmission of electricity in this excellent resource, which will help students understand the science behind the tinkering.

Common Core Connections

- **CCSS.ELA-Literacy.RI.4.7.** Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.
- **CCSS.ELA-Literacy.RI.5.3.** Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.
- **CCSS.ELA-Literacy.RI.5.4.** Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.

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