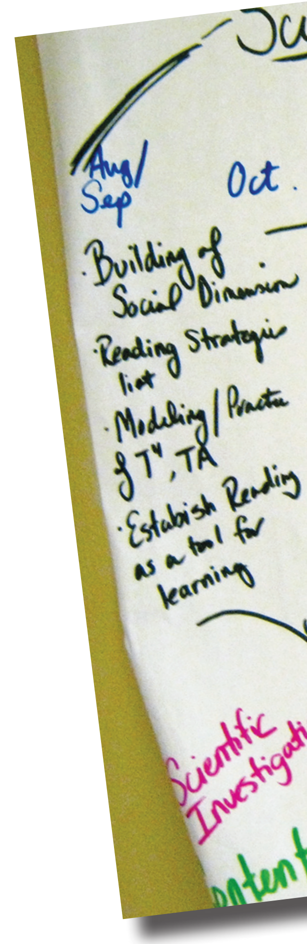



# AN ARGUMENT FOR LEARNING

## SCIENCE TEACHERS AND STUDENTS BUILD LITERACY THROUGH TEXT-BASED INVESTIGATIONS

BY CYNTHIA GREENLEAF AND WILLARD R. BROWN

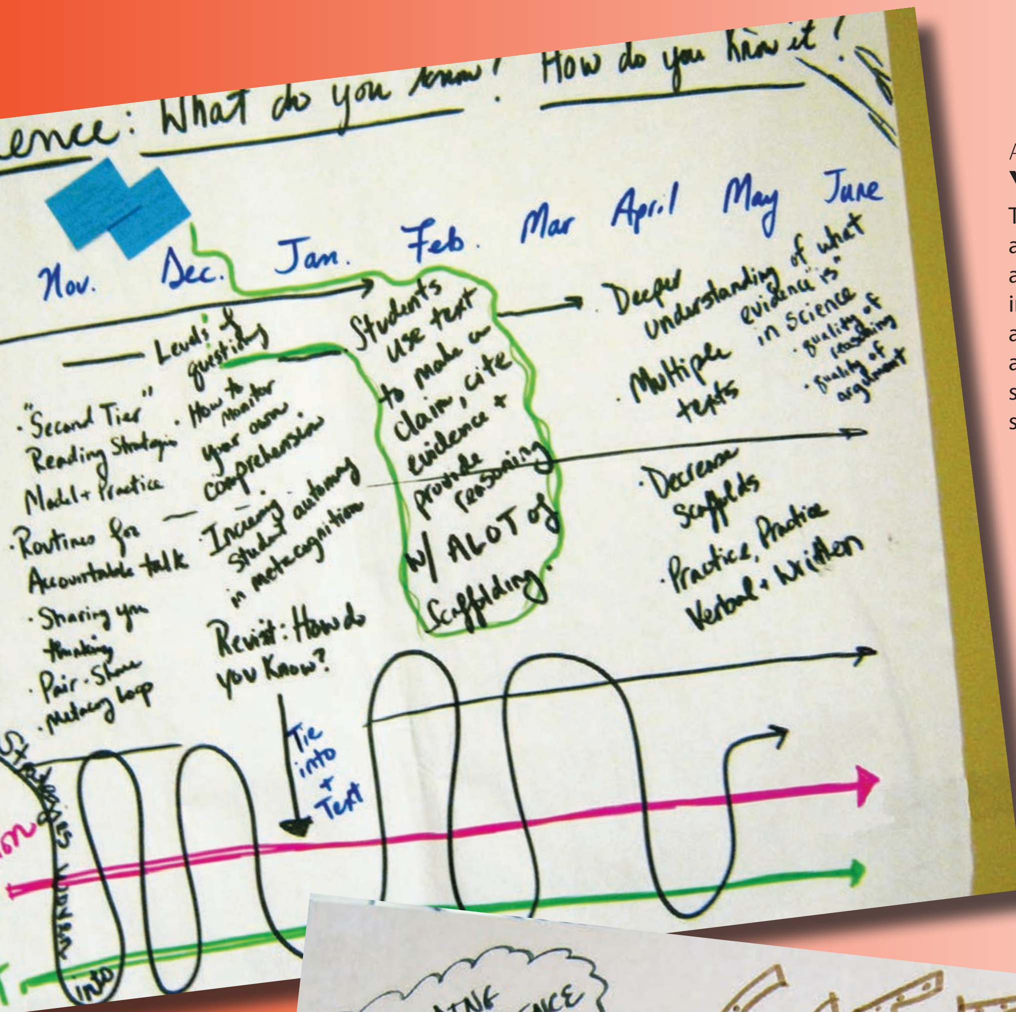
*"Argumentation is central to the practice of science. Hypotheses are constantly being tested and revised, and observations and results are spawning new questions to investigate. A focus on making argumentation a central learning process works really well with science learning."*

*— Science teacher participant, California Teacher Inquiry Network*

Scientists learn about the work of others largely through reading. They read publications in their field looking for what's new, often expecting that their understanding may change as a result of compelling new evidence. They read with a critical stance, evaluating the reliability of new findings and explanations and comparing them to existing accounts.

Most scientists also write regularly to keep track of their inquiries and share their work with others, using varied and complex forms of texts — including technical language, mathematical expressions, graphs, diagrams, models, and verbal exposition to represent their ideas. Using the inquiry process, scientists follow and engage in arguments with other scientists' work and build models and explanations of the phenomena they study. Through these recursive practices of reading, reasoning, modeling ideas and revising them, robust scientific knowledge develops over time.

The Next Generation Science Standards call for teaching the *practices* of science and engineering to build students' understandings of the nature of science and increase their ability to participate in scientific inquiry, with the ability to engage in evidence-based





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AT LEFT

**YEAR 1**

Teachers in the first year, creating a learning progression for argumentation, focused on explicit instruction in the structure of argument using claims, evidence, and reasoning, applying these structural categories to various settings in the classroom.

BELOW

**YEAR 2**

In their second year, the science teachers created a representation of a learning progression for argumentation depicting three interwoven strands of instruction: scientific investigation, content, and strategies.

argumentation being a central aspect of these practices. The Common Core State Standards also promote evidence-based inquiry and argumentation that results from close reading and interpretation of varied forms of scientific communication.

Learning science requires shifting from learning *about* scientific ideas to figuring out *how* and *why* particular phenomena happen, and identifying, synthesizing, and evaluating evidence that supports and challenges these claims. In this vision, as learners participate in scientific practices such as reading, modeling, and reasoning about what others have found, and writing what they themselves find, students gradually gain access to the language, norms, and habits of mind of the scientific community.

However, science instruction is often framed as knowing correct answers to questions that teachers pose, and typical science textbooks present science knowledge as a set of well-established facts and theories. Thus, students are socialized to scan texts for information rather than to engage intellectually with texts to construct deep understanding or to use texts as sources for inquiry.

Instead, students need opportunities and environments for learning that positions scientific knowledge as hard-earned, discovered, and very often tentative in nature. Students need scaffolded support to question; make sense of texts, data and information; and build knowledge. This kind of orientation to science and science learning is absent from many science classrooms in the United States today (OECD, 2016).

## A DISCONNECT FOR SCIENCE TEACHERS

For students to be able to learn how to engage in the scientific and literacy practices envisioned in the Next Generation Science Standards and in the Common Core standards, science teachers themselves must first come to understand and value these practices. Many science teachers have a limited understanding of and limited opportunities to engage in evidence-based-argumentation as envisioned in these standards. At the same time, science teachers often lack knowledge and experience with inquiry and are inexperienced in the pedagogies needed to support it (Anderson, 2002).

And while science teachers are relatively skillful at reading science materials, their very expertise can make it hard for them to see the difficulties these materials would present for students. As a result, many are skeptical about the role and value of literacy in learning science.

In addition, science teachers do not see themselves as literacy teachers. They view teaching strategies and skills for making sense from text as the job of the English language arts or reading teacher. However, reading and understanding scientific ideas presented in texts is different from reading texts in other disciplines (Heller & Greenleaf, 2007).

## READING APPRENTICESHIP APPROACH TO DISCIPLINARY LITERACY

Together with our colleagues in the Strategic Literacy Initiative at WestEd, we have supported discipline-specific literacy through inquiry-based teacher professional learning networks (Schoenbach, Greenleaf, & Murphy, 2016) in middle schools, high schools, and colleges using a design-based research approach (Brown, 1992). In this process, we have iteratively developed, tested, and refined and broadened the scope of a pedagogical approach we call the Reading Apprenticeship framework (www.readingapprenticeship.org).

The Reading Apprenticeship framework emphasizes an integration of affective and academic engagement with metacognitive conversation at the core of classroom talk. Metacognitive conversation, focused on "making the invisible visible," enables teachers to make their own sense-making processes transparent and accessible to students and to support students' growth as more engaged and productive readers of complex sources in the subject areas (see Schoenbach, Greenleaf, & Murphy, 2012).

We have worked in-depth with science teachers using and further developing the Reading Apprenticeship framework in a variety of networks for more than 15 years. Most recently, from 2011 to 2015, we worked with science teachers in the California Teacher Inquiry Network, a network of middle and high school science teachers implementing evidence-based argumentation as outlined in both the Next Generation Science Standards and the Common Core State Standards.

The California Teacher Inquiry Network was part of Reading, Evidence, and Argumentation for Disciplinary Learning (Project READI), a multidisciplinary, multi-institution collaboration supported by the U.S. Department of Education Institute of Education Sciences (**www.projectreadi.org**).

We recruited teachers for the California Teacher Inquiry Network who had participated in Strategic Literacy Initiative's Reading Apprenticeship professional learning networks. Some of the science teachers participating had experience looking closely at the invisible processes involved in reading, thinking, talking, and writing in science.

But the focus of this network on "evidence-based argumentation across multiple texts" took them into new territory and led to new ways of working with evidence, argument, and text in teaching inquiry in science. As one participant noted, "Participating in the READI network has helped me understand the role of literacy in science education. I have learned about many techniques that have helped me help my students understand their readings better. Previously, I have thought of science education as most valuable when it is 'hands-on' and 'inquiry-based.' However, I have begun to see that close reading and reading for meaning allow students to use their reading as a type of inquiry."

## PRACTICING SCIENTIFIC ARGUMENTATION

One of the hallmarks of the Reading Apprenticeship approach to professional learning is that teachers actively inquire into the processes by which they work through comprehension problems in texts. They learn the art of making their invisible thinking processes visible. This helps them see more clearly that they have internal resources to help students master similar kinds of thinking processes.

Participants in the California Teacher Inquiry Network learned how to use texts as resources for inquiry, deepen their understanding of disciplinary argumentation, and explore what is involved in developing models to explain scientific phenomena. Teachers explored the argumentation practices specific to their disciplines through multiple readings, discussions, and re-examination of their beliefs and practices about scientific argumentation.

In the first year of the network, science teachers generated their own claims and wrote arguments as they engaged in reading complex disciplinary texts. Through this process, they became more attuned to what makes a sophisticated argument and to the kind of language and nuanced thinking they wanted their students to begin to practice.

As teachers expanded and deepened their own notions of what constitutes argumentation in their disciplines, they were better able to articulate the discrete steps students need to "argue to learn" across texts. Teachers then began to build appropriate instructional scaffolds for students.

From the first to the second year of network meetings, professional learning led to fundamental shifts in teachers' understanding of evidence-based argumentation. Teachers reported that their own changes in understanding of evidence-based argumentation impacted classroom practices. Key elements of the changes included using the discourse of argumentation, changing their ideas about what constituted an argumentation task, and understanding the complexity of the argumentation process.

Teachers in the first year, creating a learning progression for argumentation, focused on explicit instruction in the structure of argument using claims, evidence, and reasoning, applying these structural categories to various settings in the classroom.

In their second year, the science teachers created a representation of a learning progression for argumentation depicting three interwoven strands of instruction: scientific investigation, content, and strategies. Their progression started with supporting and building on Reading Apprenticeship routines such as building the social dimension for engaged intellectual work, constructing a reading strategies list, and metacognitive routines for fostering and mentoring close reading such as think-aloud.

Teachers viewed these supports for close reading as necessary components for supporting argumentation. To dig into argument in science, students would need not only to understand structural features of argument, but also to monitor their own reading processes and comprehension.

In analyzing these different learning progressions, we identified a shift from year one's focus on the structural aspects to an "immersion orientation" to argumentation (Cavagnetto, 2010, p. 351), a shift toward embedding argument *within* student explorations of science principles rather than as a culminating activity. Teachers created text-based units in which evidence-based argumentation across multiple types of text occurred throughout the inquiry as students generated questions, designed experiments, interpreted data, and constructed and defended evidence-based knowledge claims based on their evidence.

A major trend in teachers' year-end reflections was the redefining of argumentation from a formal product such as an essay, debate, or presentation to an argumentation process and a set of routine practices (see the diagrams on p. 57).

## TEXT-BASED INVESTIGATIONS

To provide students with the opportunity to carry out evidence-based argumentation, we developed what we called text-based investigations in partnership with science teachers in the network. In this approach, science text sets are built intentionally, from authentic science sources, to engage students in purposefully reading and learning to make sense of the multiple modalities characteristic of science texts to help understand and explain the science phenomenon.

Teachers engaged in investigations to design the inquiry tasks and built scaffolds for engaging students in them. They then implemented and tested the impact of this work on students' science practices with texts in their classrooms.

Organized around developing evidence-based arguments from multiple and varied sources, these investigations provided students with multiple opportunities to develop and critique their own and their peers' causal explanations for such phenomena as the emergence of antibiotic resistant strains of bacteria and the contamination of water sources in agricultural and industrial areas impacting city water supplies. Culminating tasks focused on constructing and critiquing multimodal texts — visual and verbal explanatory models for the phenomena of study.

This approach engaged students in reading authentic science texts of varied genres and modalities — data tables, maps, diagrams, informational texts, case studies, and science research reports, often in excerpted form, to carry out investigations of a phenomenon of study.

Given the complexity of reading for understanding in science and the inexperience of students in treating text as a resource for inquiry, students needed support for making sense of individual texts, synthesizing ideas across texts, negotiating conceptual changes, constructing models and explanations, and engaging in science argumentation. Engaging students in this intellectual work required that teachers foster a culture of collaboration and discussion to support knowledge building and evidence-based argumentation.

### CHANGING CLASSROOM CULTURES

Many studies have found that students develop academic skills and affective dispositions by engaging in challenging work with ample instructional support, rather than in simplifying tasks or focusing solely on skill-building exercises (Yeager & Walton, 2011). Research documents the effectiveness of interventions aimed at shifting students' explanation of setbacks from stable internal causes — "I'm no good at science" — to temporary external causes — "This is really hard, and I need help to get it." These learning strategies involve metacognition, self-regulation, and cognitive strategies for reorganizing texts and content — processes that contribute to deeper understanding, improved academic performance, and feelings of self-efficacy.

The culture of many classrooms, however, does not support peer interaction or help students develop the dispositions needed for the hard work of comprehension. In many middle and high school classrooms, a culture of going through the motions to gain information at a surface level is pervasive.

When classroom cultures and conversations shift so that students are discussing science phenomena in the classroom, teachers also benefit from this as a form of formative assessment: Students' current conceptions become apparent and teachers can organize instruction responsively to deepen these conceptions.

### CHALLENGES AND LESSONS LEARNED

While working with teachers to implement text-based investigations, we realized that these necessary pedagogies were new to many teachers. Providing support for students' close reading of a variety of complex science texts and representations and for the growing use of discourse practices to support explanation and argumentation required perseverance from the teachers involved.

Building classroom cultures that held students accountable for doing the intellectual work while providing this kind of support when students themselves sometimes questioned the need to do the kinds of deeper thinking required tested teachers' beliefs in the value of this level of rigorous inquiry.

Documentation and analysis of California Teacher Inquiry Network teachers' initial attempts to conduct text-based investigations made it clear that we needed to help them establish classroom norms for intellectual work, close reading, and collaboration. Text-based investigations could not merely drop in to existing traditional instructional environments. To implement text-based investigations, teachers needed to learn new ways of working in the classroom.

Importantly, teachers learned to do this instructional work by carrying out text-based investigations themselves, reflecting on their own reading and reasoning processes in the California Teacher Inquiry Network, and carrying these insights into the classroom. As a result:

- Teachers' understanding of disciplinary argumentation deepened. They came to understand the processes involved in argumentation and moved from seeing argumentation as a product at the end-point of instruction to a process that permeated instruction and set the purpose for closely reading documents.
- Teachers developed instructional scaffolds and became more explicit in their support for close reading for students to build their own interpretations and arguments based on evidence they collected.
- Teachers and students gained experience working across texts simultaneously and forming arguments supported by textual evidence.

Our work with the California Teacher Inquiry Network subsequently became the basis for professional learning with a group of science teachers in Chicago. These teachers were part of a randomized control study that found

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An argument for learning

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promising results in changes in teachers' practices and student learning.

The study found that 9th-grade biology students in the experimental condition outperformed students in control group classrooms on two measures of science comprehension across multiple texts that required reading, synthesizing, explanatory model building, and argumentation (Goldman et al., 2016).

Results such as these show the promise of preparing teachers to teach inquiry-driven literacy and science practices as a process of actively making meaning. This type of inquiry-based professional learning may be especially important in the context of science — a field driven by inquiry practices — and when teachers are being asked to teach in ways that are substantially different from how they were taught or how they learned to teach (Borko, 2004).

To do so, teachers will need support for their own learning over time with opportunities to learn that mirror these forms of inquiry (Pearson, Moje, & Greenleaf, 2010).

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