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WINTER 2019–20

Promoting Discourse in Science Class

> "...Students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined."
>
> **National Research Council**
> *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*

That statement by the National Research Council (NRC) of the National Academies sums up the value placed on student talk and scientific argumentation in the Next Generation Science Standards* (NGSS) and other science standards based on the *Framework*. But it also represents a change in the structure of a science lesson where a teacher disseminates information and students provide the one correct answer to a teacher's question. It requires that students be active participants in their learning—that they share and support their ideas even if the ideas are not that "one correct answer."

"Teachers are working hard to develop strategies to help students say, 'I can do this,'" Hoover Herrera explains. Herrera, a customer success and curriculum marketing manager for Carolina Biological Supply Company, is a master math teacher and national training specialist who has turned his expertise to help teachers recognize, promote, and assess discourse in the science classroom.

"All students come into school knowing things, and discourse draws on their funds of knowledge," he says. "But because of immediate gratification—everything they do is fast—we need to try to get students to slow down and think . . . Science is thinking. We need to guide them through discourse to make their thinking visible to others."

Scientists and engineers…

- Use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits
- Engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims

(NGSS Lead States 2013, 397)

Discourse Vs. Scientific Discourse

Discourse is the verbal exchange of ideas, or simply, talking. *Scientific discourse* involves argumentation based on evidence to persuade colleagues—or classmates—that ideas are valid. The NGSS calls for science learning to be mediated by productive argumentation supported by evidence, collaboration, and analysis. (NSTA 2015)

"Skill and persistence are required to help students grasp the difference between scientific argument, which rests on plausibility and evidence and has the goal of shared understanding, and everyday argument, which relies on power and persuasiveness and assumes that the goal is winning," the NRC says in *Taking Science to School: Learning and Teaching Science in Grades K–8*. (NRC 2007, 187–188)

Today's standards focus on a three-dimensional approach—science and engineering practices, crosscutting concepts, and disciplinary core ideas—that engages students in sense-making through hands-on investigations and exchanging ideas, or discourse.

"Instead of providing them with a right or wrong answer, we're trying to get them to make those connections for themselves," Emily C. Miller, an NGSS writing team member, explains as part of a National Science Teaching Association video on supporting talk in the classroom. "We're saying, 'What are your ideas?' and then we're seeing all of them as valuable, and we're helping those kids understand that [their] ideas are actually really wonderful and make a lot of sense." (NSTA 2015) This can be a significant shift from the classroom culture where the teacher initiates the questions, a student responds (or breathes a sigh of relief when another classmate responds), and the teacher evaluates the response.

"We need to shift thinking from answer-getting," Herrera explains. "When a student responds, it doesn't matter if the answer is incorrect, incomplete, or correct. It's now about the evidence. With the question, 'What did you observe?' there's not a right or wrong answer. I tell teachers to develop a poker face that doesn't give away what they're thinking. Whether the answer is right or wrong, the teacher is going to ask why—to ask for the evidence to understand the student's thinking."

NGSS Science and Engineering Practice 7: Engaging in Argument from Evidence	
Grades K–2	**Grades 3–5**
Engaging in argument from evidence builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). *Students observe images to look for evidence that living things can change their environment. They offer examples of how their own actions can also change their environment.*	Engaging in argument from evidence builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). *Students write and share a public service announcement about a solution that is used to protect Earth's resources. Students critique these solutions based on the needs of their local area.*
• Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations. *Students compare different materials to construct an argument for which is best suited for a specific task.*	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. *Students plant seeds in different conditions and make observations to collect evidence for what plants require to grow successfully.*
• Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. *Students engage in a class discussion to argue how mountains, valleys, lakes, rivers, and islands form.*	• Respectfully provide and receive critiques from peers about a proposed procedure, explanation or model by citing relevant evidence and posing specific questions. *Students use stream tables to model a solution to prevent soil erosion and compare their results to their peers.*
• Construct an argument with evidence to support a claim. *Students build and test a string phone to support the idea that sound can travel through solid materials.*	• Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect. *Students investigate mixtures to gather evidence for physical and chemical changes.*
• Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence. *Students model how pollen or seeds are distributed and discuss how effective each method is.*	• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. *Students compare forms of renewable energy and make a claim about which method would be most effective in their area.*

(NGSS Lead States 2013, 397)

Examples in italics are from Building Blocks of Science™ 3D curriculum.

> … encourage students to ask each other questions—‘the holy grail of discourse’…

Orchestrating Productive Scientific Argumentation

When considering an essential question of a unit, Herrera recommends a **change in philosophy**. Instead of asking, “How can I teach my kids to get the answer to this question?” ask, “How can I use this question to teach the science of this unit?” The teacher can start a teacher-to-student discussion to make sure all students are involved but then serve as a bridge between students and promote active listening.

Develop questions, Herrera says, that **encourage students to take risks and build knowledge**. “We want everyone to talk. All students, whether they are strugglers or advanced learners, need to be involved in discourse,” he explains. “Start with the struggling learners but give them a question that’s challenging enough to give them an opportunity to think but not so hard as to deter them from participating. If students feel confident and safe, they’ll also want to participate more.”

Recognize that **prior knowledge can be an asset or a hinderance**. As an asset, it demonstrates knowledge and understanding of the disciplinary core ideas. But prior knowledge can hinder sense-making if it is incomplete or based on misconceptions. “The teacher needs to discover the root of the misconception and lead students to that aha moment when they figure out the correct answer,” Herrera says. “Keep probing through discourse: ‘Why do you think that …?’”

Among his discourse-promoting strategies, Herrera suggests that teachers **encourage students to ask each other questions**—“the holy grail of student discourse”—or **provide incomplete data** so students need to figure out the missing information. When available, use an interactive whiteboard to have students write or draw their thoughts, leading to a whole-group discussion of who agrees, disagrees, and why. “These are strategies that can be used with any grade level and really in any subject,” he says.

In addition, **use a curriculum that specifically highlights discourse opportunities** to support teachers in prompting students, Herrera says, citing the Building Blocks of Science™ 3D curriculum’s “Tell Me More!” questions as examples. “There is no one perfect answer to these questions, but the [students’] answers are what teachers can use to engage students in discussions.”

Tell Me More!

Explain how a shadow can occur at night if we can observe the Sun only during the day.

“Of course, different publishers give different labels to their student discourse/discussion opportunities,” he explains. Herrera advises using a curriculum that goes beyond just encouraging discussions by explicitly calling out to teachers when, where, and how to engage students in discussions.

Differentiation Strategy

Differentiation Tip

For high-level thinking, challenge students to come up with examples of plants that could be considered predators, and what adaptations they would need to have. You may wish to follow up with a discussion and video clip on carnivorous plants, such as the Venus flytrap.

From Building Blocks of Science 3D: Life in Ecosystems

> What evidence will convince you that they [students] reached the goal of understanding?

Assessing Understanding

Science standards based on the *Framework* encourage teachers to consider the degree to which the three dimensions contribute to sense-making, leading Achieve to draft a framework to help evaluate the cognitive complexity of assessment tasks. (Achieve, Inc. 2019) Students not only need to know science concepts but also must *apply* their understanding (NGSS Lead States 2013, 382), and teachers, the *Framework* says, ". . . need to learn how to use student-developed models, classroom discourse, and other formative assessment approaches to gauge student thinking and design further instruction based on it." (NRC 2012, 256)

So Herrera poses this question to teachers: "What evidence will convince you that they [students] reached the goal of understanding?"

Written and physical evidence oftentimes present the obvious indicators of learning. But verbal evidence, Herrera says, where students need to put their thinking into words, can be the most challenging as students struggle to express their ideas and teachers endeavor to determine the level of sense-making that students are demonstrating.

In *Ready, Set, Science! Putting Research to Work in K–8 Classrooms*, the NRC offers the following six talk moves to encourage discourse and help students verbalize their reasoning. (NRC 2008, 91)

- Revoice what a student said.
- Ask students to restate a classmate's reasoning.
- Ask students to apply their own reasoning to a classmate's reasoning.
- Prompt students for further participation.
- Ask students to explicate their reasoning.
- Use wait time.

These talk moves and strategies give students practice developing and articulating their thoughts, providing the evidence teachers need to assess the levels of sense-making. But as teachers guide students to take thinking to a higher level, the intended outcome of scientific discourse needs to be at the forefront of the interactions: students are presenting ideas and evidence not to win an argument or to provide the one correct answer but rather to respectfully encourage one another in discovery as they work as scientists and engineers to figure out a phenomenon.

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Building Blocks of Science™ 3D

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