The Driving Question Board:
Putting Students at the Helm of Science Learning

> "Questions are the engine that drive science and engineering … Asking questions is essential to developing scientific habits of mind."
>
> (NRC 2012, 54)

Those words from the National Research Council (NRC) of the National Academies in *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* signify the importance of students developing the ability to ask good questions and clearly define problems to achieve understanding about phenomena. Asking questions and defining problems is the first of eight scientific and engineering practices (SEPs) identified in the *Framework* and is key to achieving performance expectations in the Next Generation Science Standards (NGSS)* and other standards influenced by the *Framework*.

"Students of any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations," the *Framework* states. ". . . Facilitating such evolution will require a classroom culture that respects and values good questions, that offers students opportunities to refine their questions and questioning strategies, and that incorporates the teaching of effective questioning strategies across all grade levels" (NRC 2012, 56).

One powerful tool that supports that classroom culture in three-dimensional science education is the driving question board (DQB). A DQB is a public display of student questions about a puzzling or intriguing event that drives learning forward. More than a visual reminder of what questions students have asked, the DQB is a mechanism to value student backgrounds and experiences and then build student understanding of science concepts as they use evidence to revise their thinking and track, revisit, and answer their questions about the event or phenomenon.

The DQB is a central element of OpenSciEd middle school units, all of which have been identified as Quality Examples of Science Lessons and Units and most of which have received the NGSS Design Badge—the highest rating of excellence from the rigorous Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for Science (NGSS 2022).

"What is unique about three-dimensional learning is the opportunity for students to be involved in the thought process and decision-making about what the class should be figuring out and how the class should be figuring it out," OpenSciEd Curriculum Director Sarah Delaney explains. "It [the DQB] is about engagement and ownership of the learning and making it very clear what we're trying to make sense of and how we're going to go about doing it."

"Student learning is driven by their questions," OpenSciEd Outreach Director Matt Krehbiel adds. "The DQB draws in students who maybe haven't thought that science is relevant to their lives before. Because now, the reason for my learning is, 'I've got these

Credit: Courtney Baker, Haddonfield Middle School, Haddonfield, New Jersey

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> —Sarah Delaney

questions about this thing that's happening in the world that I don't quite understand and we're going to figure that out together as a class.' This shifts the ownership for learning to the students."

Questions in Science

In science, asking questions can be as important as discovering answers to those questions. Scientific questions lead to answers found in explanations supported by empirical evidence, including evidence gathered by others or through investigation (NGSS, n.d.).

When investigating phenomena in a three-dimensional science classroom, students' questions should eventually:

- Go beyond yes/no answers
- Require answers that explain how and why a phenomenon works
- Demand empirical evidence
- Lead to explanations and models that advance knowledge and apply that knowledge to new situations

(Schwarz, Passmore, and Reiser 2017, 100)

With the DQB, the goal isn't to begin an investigation with the perfect question. From a preassessment standpoint, it's important to not apply too many restrictions to get a true picture of students' understanding at the beginning of a unit. Questions can be driven by wonderment and curiosity, can be answered empirically through the investigations, or can be explanatory.

"Initially, it's totally owned by the student. It's their way of thinking and seeing the world in their questions, and so we're putting up and honoring it and using it as a guide," Delaney says. "Any way the student phrases the question is fine as long as it makes sense to the student, so they're not feeling limited by lack of academic language. Later on in the unit, students will learn the formal vocabulary for what they are describing."

By regularly using a DQB intentionally throughout the year, students learn to recognize what makes a well-defined scientific question. "You get their questions out and talk about them as a class," Krehbiel says. "Ask things like 'Which of these questions do we think we can answer with evidence?' or 'Which of these questions can we do investigations on?' Over time, students get better at asking scientific questions without having to do a separate precursor exercise on 'How to Ask a Scientific Question.'"

NGSS Practice 1: Asking Questions and Defining Problems Progression

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Builds on prior experiences and progresses to asking simple descriptive questions that can be tested	Builds on prior experiences and progresses to specifying qualitative relationships	Builds on prior experiences and progresses to specifying relationships between variables and clarifying arguments and models	Builds on prior experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations

(NGSS Lead States 2013, 51)

Implementing the DQB

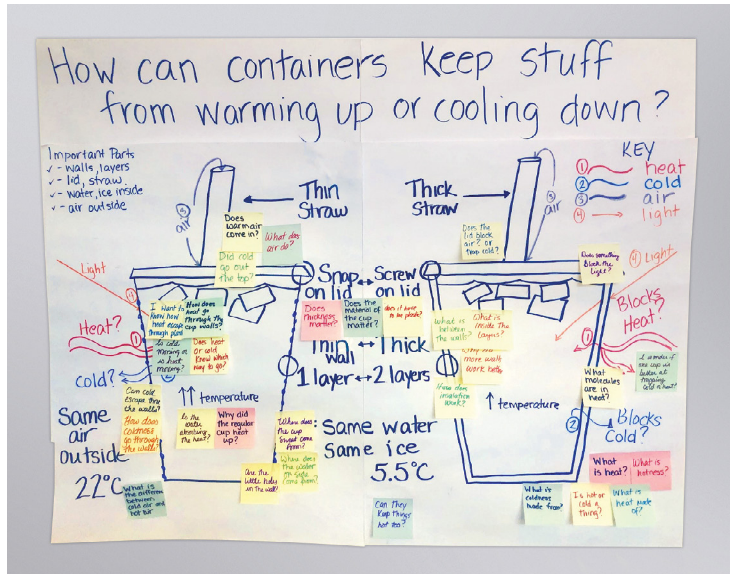
"There's a lot of intentionality to the physical setup of the classroom to really establish the understanding that we as a community have all these questions and now we want to figure them out," Delaney says. The DQB can be as simple as a large sheet of poster board displaying the unit question or can be a shared software application, but it should be easily accessible to all students to establish it as a resource that's driving learning.

There's also design that goes into the process that leads up to preparing questions for the DQB so students can find success in it. In OpenSciEd middle school units, an anchoring phenomenon routine occurs over several days to spark curiosity and help students develop questions (OpenSciEd 2020, 14–16).

- Introduce a puzzling, relatable phenomenon and have students as a learning community focus on what they notice, make observations, look for patterns, and consider what about the phenomenon needs to be explained.
- Invite students to try to make sense of what is happening, voicing their initial ideas even if they're inaccurate. This generates ideas that lead to questions and initial explanations they'll want to investigate. It's important for students to individually make sense of the phenomenon and then go public with their ideas.
- To build disciplinary core ideas and crosscutting concepts that can be applied to other events, students identify related phenomena, creating a personal connection and investing them in the class exploration.
- Students individually post a question on the DQB. "When we get to this point, students are prepared. They've been able to think about this," Delaney says. "They know what their question is. . . . And as students get comfortable with this routine, they get better and better at asking questions and thinking outside the box a bit."

From that point on, the DQB guides the lesson's investigations. Related questions are displayed together, and students consider actionable ways to answer a question as a class. Throughout the investigation, students revisit the DQB, reviewing what they have answered and considering what they want to answer next.

Krehbiel, who provides professional learning to educators, acknowledges that introducing a DQB for the first time to students doesn't always go smoothly. "This is a very different experience for some teachers. The students aren't used to it, and the teacher isn't used to it," he says. "Any big change in instructional practice is not going to go perfectly the first time. But the teachers who keep after it and figure it out talk about how it can be a transformational experience for them and their students."



Credit: OpenSciEd

The DQB as part of the three-dimensional science learning process can "unleash the curiosity and creativity and intellectual capabilities" of students, Krehbiel adds, leading teachers to realize that students are capable of doing more than anticipated.

"Start where they're at, value that, think about their knowledge and experiences, and build on that foundation," he advises. ". . . The result will be a powerful impact on student learning."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Equitable and Relevant

The DQB lays out a welcome mat for every student to have a voice in the conversation about the phenomenon being investigated—drawing out and valuing the knowledge and experience students bring to the classroom—and promotes equity while listening to every student's wondering. But it also requires a transition for students who have historically sat quietly, working to absorb what the teacher is saying.

"We have structures built in to support our kids feeling safe to share their ideas, but it's also important that the teacher highlights and celebrates diverse perspectives," Delaney says. "It's scary to ask a question that is different from anyone else, but that's often the most valuable thing, and we want teachers to celebrate that."

With the DQB, the focus shifts to a collective learning adventure, with every idea and life experience helping the class move forward.

"If it's facilitated well, it's an opportunity for students who have struggled in school—whether they're emerging multilingual learners, in special education, or marginalized due to their race, ethnicity, or gender—to find their voice and engage in meaningful science," Krehbiel says. When students realize that others in the class share thoughts similar to their own, it validates their ideas and draws them further into the discussion.

As part of learning, students are encouraged to connect the phenomenon to something comparable to their personal experiences. As students become familiar with the process, they begin to routinely transfer understanding. "As a result, students say the learning they're doing is relevant to them," Krehbiel explains, adding that surveys across all demographics demonstrate this. "In OpenSciEd's middle school field test, more than 90 percent of students say, 'The learning I'm doing in the classroom is relevant to me' and part of that is because their questions are being answered from the driving question board."

A LESSON EXAMPLE: **Sound Waves**

Phenomenon: How can a sound make something move?

Lesson: How does a sound source make something like this happen?

Day 1: Begin by engaging students in a common experience involving the phenomenon: a video of a man in a truck turning on loud music, leading windows across the parking lot to shake. (OpenSciEd, n.d.)

Students make observations, write what they notice and wonder, and then have a conversation about it. The class dives a little deeper and agrees that the speakers are making the noise. Students realize that maybe they can look at the speaker to see what's going on. Students watch a slow-motion video of the speaker, generating additional questions.

Day 2: Students create individual models to show what they think is happening with the phenomenon. The class compares the initial models and develops explicit, shared norms between them. After sharing similarities, differences, and uncertainties, the class considers a consensus model. At this point, students know a speaker and a window are involved, Delaney says, but there are question marks everywhere.

Day 3: Students choose a focal norm and share ideas of related phenomena and experiences they have had. The teacher asks, "Have you ever seen something like this before? Does it remind you of anything else?" This promotes more shared observations and wonders.

Each student looks through everything they've done so far and writes on a sticky note—nice and big with a black marker—the one question that they really want to figure out. They put their name on the back of the sticky note with pencil.

Students form a physical circle—a Scientists Circle—to construct a DQB. The teacher is behind the students, giving students ownership of their learning. One student begins: "I'm wondering" and says the question aloud to the class. Students with similar questions raise their hands. That student chooses another student to read their question. As questions are read, they're grouped by topic area on the DQB. When all students have posted questions, the result is a DQB filled with wonders.

Students determine what question they want to investigate first and brainstorm actionable ideas that can answer that question.

Day 4+: Students come back to the DQB throughout the lesson, revisiting questions they have answered and considering what they need to answer next. In closing the lesson, students may take their sticky notes from the DQB and say what the answer is, providing proof that all the questions they developed have been answered.

"One of the things that I love about this is if you walk into a classroom and ask a student, 'What are you doing and why are you doing it?' there's never the response that 'This is the assignment for today' or 'I don't know' or 'We're filling out a worksheet,'" Delaney says. "The answers are always, 'We're trying to figure out our question,' so it really makes that wondering and curiosity visible."

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curriculum@carolina.com

800.334.5551

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