[MUSIC PLAYING]

SPEAKER 1 (VOICEOVER): In a middle school classroom, a unit about how gases behave is anchored in the question of, what would cause a railroad tanker car to do this? Over three weeks, students engage with a number of science ideas and investigations to generate and revise explanations for this phenomenon.

In a third grade classroom, students puzzle over the case of a singer who can break a glass with just the sound of his voice. These young learners are also asked to integrate a number of science ideas and investigations to create plausible models for this event.

In a sophomore biology class, students examine the decline of the killer whale population in Puget Sound. This phenomenon becomes the basis of three weeks of study on ecosystems and all the ideas that advance our understanding of this part of the natural world.

These learning opportunities sound exciting for students and science teachers as well. But how can we plan for these kinds of units and ensure that standards are met along the way? This video describes the first of four sets of practices that make up ambitious science teaching.

This first set is referred to as planning for engagement with important science ideas. There are three practices involved. The first is to unpack your curriculum and the standards around the topic you intend to teach. The second is identifying and anchoring phenomenon and its explanation. And the third is organizing a sequence of learning experiences for your students.

The goal of these planning practices is to design a set of learning experiences that students can recognize as coherent with each other and cumulative in building big ideas. Experiences that challenge learners, not just to understand concepts, facts, and formulas, but to solve authentic problems, engage in disciplinary practices, like modeling, explanation, investigation, and argument, and to become increasingly capable of learning with others.

What do these practices look like? The first step is to unpack the curriculum and the standards. Teachers typically center their units around topics like homeostasis, force in motion, earthquakes, or chemical reactions.

By unpacking, we mean looking at the standards and identifying where your topic shows up. You then look at your curriculum and identify what parts of your topic are addressed there. We'll show you now what this looks like as we do this work with a group of teachers.

SPEAKER 1: And begin your work with the Next Gen standards. Try to find about six disciplinary core ideas that are most connected to your topic, and then write those down on post-it notes. And then, don't try to prioritize them. In the first stage, I just want you to line them up on the bottom of the whiteboard.

SPEAKER 1 (VOICEOVER): In this planning activity, my teachers have already selected topics for their units, like homeostasis, force in motion, earthquakes, or cellular respiration. I then asked them to look in the Next Generation Science Standards at the appropriate grade levels to find between four and six standards that are related to their topic. These are recorded on sticky notes and placed along a whiteboard.

I then asked them to repeat the process, finding four to six big ideas from their curriculum. They then have to place at the center of their whiteboards two or three ideas from the standards or from their curriculum that have the greatest explanatory power, meaning ideas that are levers for understanding a range of other ideas. These will become instructional priorities for them as they continue planning.

SPEAKER 1: What did you write down? What is your topic?

SPEAKER 2: Homeostasis.

SPEAKER 1: OK. So can you pull those off and just show me what you thought were the biggest ideas closely related to that?

SPEAKER 2: So the most important that we thought were that it's about maintaining an organism's internal conditions as a function of feedback loops either positive or negative, that that's what and the how. And those are the things that we thought were most important. And then, some things that are important to touch on outside of that is that it's in response to an external environment.

SPEAKER 1: Yeah, that's big. It's almost the other half of this-- maintaining internal conditions in light of the external environment.

SPEAKER 2: So the ideas-- we're talking about homeostasis. And the ideas that we're really prioritizing from the standards are that homeostasis is the maintaining an organism's internal conditions, that's what it is, and how it's achieved is through positive and negative feedback loops. That's the mechanism of those.

SPEAKER 1: And if they understood those, why would it help them understand other things?

SPEAKER 2: Understand homeostasis, or--

SPEAKER 1: Other science ideas you have, from the standards or from the curriculum.

SPEAKER 2: OK. So it would help them to understand that things are in a state of dynamic equilibrium. So with feedback loops, you go up and down around an average, rather than staying at a constant temperature. I think--

SPEAKER 1 (VOICEOVER): This was the whiteboard from one of the homeostasis groups. There were six blue stickies representing ideas from the standards, and five yellow stickies representing important ideas from the curriculum. Two ideas from the standards were thought to have the greatest explanatory power. These were maintaining an organism's internal conditions and the idea of feedback loops.

A group planning for an earthquake unit had five ideas from the standards and five from the curriculum. The three with the greatest explanatory power involved convection and plate tectonics. When pressed about what was so important about convection, they added, on the left sticky, ideas about the cycling of matter and the transfer of energy.

Once you've identified the science ideas that have the greatest explanatory power, you can select or create an anchoring phenomenon for your unit. This is a complex and puzzling event or process that you'll keep returning to with your students as they build and revise explanations for it. A good anchoring event requires that students pull together a number of important science ideas to explain it.

You can tell that we stress the words "phenomena," "event," and "process." The reason is that we want students to explain something that happens over time-- to explain why it unfolds in a particular way. Some anchoring events are brief. Some take years to happen. But we always want students to explain something that does happen.

Coming up with a good anchoring event is an act of creativity. Most of our teachers need days or even weeks to develop one that works for students. This is where networks of teachers really need to share what has worked for them.

Once the anchoring event is selected, an explanation has to be written for it. This is an elaborated explanation that integrates all the important science ideas that you want students to understand. Every explanation uses unobservable events and processes to account for what happens at the observable level.

Even in kindergarten, with a phenomenon like one person pushing another off the end of a playground slide, the explanation will include forces, gravity, and energy being transferred between one person and another. To provide another example, we'll use a sophomore-level biology class where students are trying to explain why a population of hares fluctuates up and down every 11 years. The teacher, Bethany, has constructed this gapless explanation and color-coded where the different science ideas are embedded. After doing this task, she's ready for the last of the three planning practices.

In the third planning practice, the teacher takes each science idea in the explanation and uses it to identify at least one activity, reading, or investigation opportunity for students. Many of these would be found in the curriculum. Some would have to be developed or transferred from other curriculum. The purpose is to make sure that every element of the full gapless explanation is addressed by one or more learning experiences.

The next step is to arrange these experiences in an order that would be helpful for students. We think of activities that would fall roughly in the first third of the unit, the middle third, and the final third. This guide shows different ways that you can prioritize what comes early, middle, and later. The three downward arrows are suggested ways to think about ordering. Starting with the left-hand arrow, you could begin the unit with more familiar ideas to students-- perhaps ideas that are more concrete. Later in the unit, you would address more abstract or unfamiliar ideas.

The middle arrow suggests that ideas that are prerequisites for other ideas could lead off the unit. Then, later in the unit, one could address ideas that require the integration of these more basic concepts learned earlier in the unit. The third option requires that we think about the flow of the causal story, or explanation. There are some ideas that come first in this causal story. Perhaps they could come first in the arrangement of the unit.

Here is the way that our biology teacher, Bethany, has laid out her sequence of ideas activities readings and investigations. It's important to understand how this kind of planning fits in with the other three sets of ambitious science teaching practices. To illustrate, we'll again use Bethany's ecology unit and this unusual diagram. It represents, from left to right, the trajectory of ideas during her unit. Remember that her anchoring event is the rise and fall of a hare population every 11 years.

Early in this unit, Bethany will use the practices around eliciting students' initial ideas and experiences about the phenomenon. Then, throughout most of the unit, she will focus on supporting changes in student thinking. These teaching practices happen in cycles multiple times, as new ideas, investigations, and readings are introduced. Bethany's job here is to get students to constantly add to and reorganize their ideas about the anchoring event.

In the final three days of the unit, Bethany will press students to use all available evidence to assemble a coherent and gapless explanation for the fluctuation of the hare population. On day one, Bethany elicits students' initial theories. Some students say that predators must be a factor. Others believe that coyotes have invaded the territory, and others believe that an arsonist sets fire to the forest every 11 years. Bethany asks students to draw out their thinking in the form of models.

On days two and three, Bethany introduces an activity around the resources that animals need to survive. On days four and five, the topic is carrying capacity and limiting factors. Meanwhile, students bring up personal experiences with invasive species, and although this was not part of Bethany's explanation, she incorporates it into all future discussions.

On day six and seven, students explore trophic levels. Days eight and nine are about the flow of energy in ecosystems. On days 10 and 11, students are asked to revise their initial hypotheses and models. Several students want to add disease as a possible part of the explanation, and again, Bethany incorporates her ideas into the unit trajectory. Days 12 and 13 are about the carbon and nitrogen cycles, and day 14 is about nutrition.

As you can see in our diagram, some of these topics are instructed by Bethany, and some are generated by students. But none of the ideas remain untouched by other ideas. Students see how concepts flow together. Some hypotheses that students initially favored are dropped, and others are reinforced as they deepen their understanding of ecosystem dynamics.

Near the end of the unit, students are asked to create final models and evidence-based explanations. In our diagram, the clusters on the far right represent the varied kinds of legitimate explanations and models that could be produced by students. These deliberate planning practices ensure that students will spend time learning important science ideas, and increase the likelihood that their understandings will be cumulative and coherent.

[UPBEAT MUSIC]