SPEAKER 1: We are now finishing the cycle of teaching practices. Near the end of a unit of instruction, students should be assembling parts of their final explanation for the anchoring event. It is at this point that the teacher asks them to select one claim that is important to their explanation, and support that claim with evidence. This is a scientific practice of argumentation.

Once his claims have been shared and debated in class, the students take all of what they've learned during the unit, and create their final explanatory models along with the written explanation.

This is not the end of the unit. The teacher may see gaps that persist in students' explanations and decide to reteach important ideas, or the teacher may ask students to apply their models to different phenomena, or the teacher may elect to conduct more formal assessments of learning to culminate their work together.

One goal of these practices is to help all students learn to use evidence to support scientific claims. A claim is an informed statement about what is or is not causing some part of a phenomena to unfold in a particular way. Another goal is for all students to be able to draw upon multiple investigations, readings, and ideas, to construct a causal account of some important natural phenomenon.

We stress that students must look at many forms of data and information, because the expectations for their final models and explanations require detail, elaboration, and coherence with evidence. We'll start by showing an example of constructing and evaluating claims. This takes place in the methods class for pre-service teachers, where we are trying to explain why the railroad tanker car imploded. Here, I make a teacher move to frame the activity.

So in this unit, we have done a lot of different activities. And we have talked in some informal ways about evidence, we've used that word, we've also used the word claims a lot, and I've asked you to do reasoning. And we've had good practice at that, but now I want us in a more formal way to do what it is that scientists do.

They have a theory about how some part of the natural world works. And after collecting some data in various ways and doing reading and talking with other scientists, they believe they have a claim, they can put a stake in the ground, and say, we think that we know this.

In this episode, we'll see the important role that scaffolding plays. I'll have my students use a tool for constructing a claim, identifying supportive evidence, then providing reasoning that links the two.

Just fold this in thirds so that you just have the left-hand column showing. So what I would like you to do in your groups is, I want you to think about one claim that you can make about the tanker. One statement that you can make about, perhaps why it crashed in a particular way or at a particular time.

My pre-service teachers play the role of secondary students. I ask them to focus just on the left-hand column. The tool provides a structure for articulating a claim first, sentence frames are provided. Then a description of the evidence, again with sentence frames, then the reasoning that links the claims with the evidence.

Our colleagues in the Ambitious Science Teaching community are still helping us try to figure out what the best sentence frames are and what the best structure is for this tool. It's a work in progress.

AUDIENCE: We believe that the change in pressure has a role.

SPEAKER 1: And then Erin responded to that.

My students struggle a bit with what counts as a claim, but I provide immediate feedback, and they eventually construct a starter argument. Here's an example. The evidence they cite in the middle portion of the tool comes from a computer simulation they did of how gases behave in containers.

We then have student groups give each other feedback on their first draft of their claims evidence and reasoning.

Erin and Rachel are going to rotate over here. And what they're going to do is they're going to listen to the persor who's staying there. The person who stays here is going to explain to Erin and Rachel what the claim is, the evidence and the reasoning, and then Erin and Rachel are going to give that person some feedback.

AUDIENCE: I mean, the evidence isn't so much about explanation. It's more just about here's--

SPEAKER 1: Trying to make sense of another group's argument is a chance to reason further about the phenomenon, as is giving them feedback, and then responding to the feedback you receive from your peers. Here's an example of feedback given to one group about their use of evidence and their revised statement on the right.

This shows the entire tool filled out. We then asked selected groups of students, who may have similar claims but different kinds of evidence and reasoning, to present their thinking to the whole class.

In three classrooms, we'll see different approaches to the practice of drawing final ideas together in models and explanations. In Carolyn's fifth grade sound unit, she wants to give her students practice in drawing new models and writing new explanations about midway through the unit rather than waiting until the end.

In Ambitious Science Teaching, the modeling requires labels for observable and unobservable features. And models usually show a before, during, and after time sequence. We have seen enormous differences in what students can draw, talk about, and write about. Usually, the talk and drawing is more sophisticated than what they can write. This means that scaffolding is needed to help students express themselves in the written word.

Here, Carolyn uses one of many scaffolds, the explanation checklist. This checklist helps students understand what to include in their models and explanation.

SPEAKER 2: Things that we are thinking about and learning about. And you may have answers that you figured out for some of these. And that's great. You may not have all of them.

SPEAKER 1: As students are drawing and writing, Carolyn moves around the room, encouraging them to refer to their summary posters on the wall. She also identifies two or three students who have included important features in their models that other students have not considered. Then asks these individuals to share their thinking with the whole class.

SPEAKER 3: Can you just say a little bit about how he makes his sound?

SPEAKER 1: We now move to Bethany's sophomore biology class today.

SPEAKER 3: So I want you to think of five things that you would need to include, at least five, that you would need to include to make that a really good explanation of the hare population. And let's make our brainstorm list right here.

SPEAKER 1: In secondary science classrooms, students can co-construct their explanation checklist with the teacher.

SPEAKER 3: You just said all of these things would need to be included in an explanation. And I'm curious how that compares to your original hypothesis that your group made. So let's just turn and talk about that for 30 seconds. Go.

AUDIENCE: My hypothesis is this was by, we both have predation in common. But in order for a good hypothesis, I think we should add all the factors.

SPEAKER 3: OK. So he's saying, his original one included this, but he thinks a good one, like we just said, would include all of these. But what I said today, you will work with your group to explain why the hare population undergoes the following changes over the 35 year period. Actually, today, I printed out a graph that was zoomed in, so it's just an 18 year period. But we need to make a checklist of all the things we're going to include.

And what I noticed is that, a lot of you use yesterday's presentations as your main source of information to make this checklist. But what I also noticed is that I didn't see a lot of people using evidence from their summary chart from all the activities that we've done in their checklist. So what I'd like to do is take about one more minute for you to look back through your summary chart, talk to somebody next to you, see what you can figure out that we haven't included yet.

AUDIENCE: If we look here.

AUDIENCE: Why?

SPEAKER 3: Did you find some something amazing?

AUDIENCE: We didn't.

SPEAKER 3: This list here, I'm going to transfer it. If you think it matches, if there's something that we have to include in our final explanation, if it is, I'll put it here. And that means, we will all be including those in our final explanation. So let's start with.

I want you to look at your ecosystem model. That's the one that you cut out the pictures and look for connections for, see if there's anything that you want. See if there's anything that you want to add or revise. Do that first. Then work with your group to make a new explanation of why the hare population goes through the cycle.

SPEAKER 1: Bethany circulates and points out gaps in students' thinking or challenges their causal stories developing in their explanations or their models in other ways. At the end of this lesson, students had completed a group explanation that incorporated more than a dozen big science ideas. They had also created final models that reflected more systems level thinking.

But Bethany also asked her students to do two things as individuals that she would evaluate and grade. The first was an analysis of how their initial explanation had changed, and what ideas or evidence had caused them to revise their thinking. This student's response states why the original explanation was changed. It links together the ideas of density-dependent limiting factors, predation, plants directly influencing the reproduction rate of hares, competition, and the transfer of energy in ecosystems.

The second was to answer a series of questions about a second ecosystem in which a new species was being introduced. The ecosystem was Yellowstone National Park, and the new species was the wolf. Students were asked to respond to a variety of questions, and to create different types of models to explain their thinking.

The assessments were demanding intellectually, but Bethany had spent a great deal of targeted time throughout the unit, focusing students on the most important concepts about ecosystem behavior and provided many opportunities for her students to reason about the intersection of their ideas and the science.

SPEAKER 4: Because what we're doing right now is we're doing real science. We're going back to our ideas. And we're thinking about the new information we have, and we're revising them, we're making them better. We're adding detail, maybe we're adding a picture. You might find post-its up here that don't really need to be revised. Don't choose those. Leave them up there. Choose the post-its that we need to modify, that we need to change.

AUDIENCE: I read more than three miles.

AUDIENCE: You got me too.

AUDIENCE: This one said, in the hot water, molecules are everywhere. In cold water, molecules are slower.

SPEAKER 5: OK. So what are you changing it to?

AUDIENCE: In hot water, molecules are less attracted from each other and they move very fast, bumping and hitting, passing the heat. In the cold water, molecules are very attractive moving slower.

SPEAKER 5: That was your idea, wasn't it?

AUDIENCE: Yeah.

SPEAKER 5: That's what I thought.

SPEAKER 1: After students revise their whole class model, we can see if and how their thinking has changed. On the before sticky notes, we can see that many students had already been exposed to the idea that molecules in a solid move more slowly than those in a liquid. But these understandings appear limited in their applicability to all parts of the distillation phenomenon.

When we look at the orange sticky notes applied near the end of the unit, we still see some evidence that students have not developed explanations for parts of this anchoring event. Other stickies, however, reveal distinct changes in thinking and language use. The orange sticky on the right describes key events starting not in the flask, but in the hot plate, and describes a chain reaction of faster moving molecules. This sticky tells about the attraction between molecules and how it weakens with distance.

This note clarifies a misconception many students had earlier, and states correctly that steam is composed of evaporated water molecules. Perhaps, the most impressive idea was written over three connected stickies. On these notes, the student claimed to have a viable theory for the brown syrup left over in the distillation flask. She or he believed that the brown material's molecules contain more atoms than the water. These, the student reasoned, were analogous to a heavy person who would require more energy to move than a lighter person.

SPEAKER 4: Think about the first post-it, the one you pulled off. Some of you read them and you were like, this does not tell me anything. What did you change, what did you add to it, or what was it missing? So what did you have to do to make a good explanation on that orange post-it that was different from the first post-it?

SPEAKER 1: In the last small group activity of this unit, Anna gives students a reduced template of the distillation model. She asks students to select four activities they had done during the unit and write out how each provided evidence for a part of the distillation explanation. The students' work told her that they needed to have a whole class conversation about evidence and the kinds of explanations she would expect from them.

SPEAKER 6: All right. So all we're going to do is, I'm just going to draw names, I just want you to tell me one thing you've heard, either from your partner that you wrote down that you heard someone else say.

SPEAKER 1: Because this was only the second unit of the year, Anna's students had time to grow in their understanding of explanation and modeling.

The teaching practices we've shown here center around the scientific practices of modeling explanation and argument. Consider how rich and conceptual content this science work was for students. There was no separation between science activity and science ideas, each supported the other.

Consider, too, how each teacher supported students attempts at ambitious learning, by providing tools, scaffolding, explicit conversations about evidence and explanation, and opportunities to try out new ways of talking, doing, and being with each other.

We leave this overview on this final note. A reminder that Ambitious Science Teaching is flourishing because educators are experimenting with new practices and new tools that are aligned with a clear vision of rigorous and equitable instruction.

AUDIENCE: This one?

SPEAKER 7: Yeah, how do we hear the string?

AUDIENCE: The string will vibrate and you will feel it moving, and then you will be able to hear it.

SPEAKER 7: OK.