SPEAKER: Every day in science classrooms across the country, teachers work miracles with limited resources and time to get their students excited about science, and to help them understand the natural world.

SPEAKER: Whether these teachers are accomplished veterans or novices to the profession, they are interested in the same question, how do I get better at my work? The challenge for them and for all of us in the science education community, is that there has been no clear public image of what getting better might look like.

SPEAKER: We know that instructional excellence means more than teaching to a new set of standards, more than using an interesting curriculum or set of activities and more than just deepening our own content knowledge. There has to be a bigger picture. This is where Ambitious Science Teaching comes in. It is what better can look like.

SPEAKER: Ambitious Science Teaching is based on a comprehensive vision of teaching and learning. This vision is informed by an accumulation of evidence about what works for students of all backgrounds.

Over the past 30 years, researchers collaborating with educators have come to a great deal about how students understand the discipline of science, how they learn to write and talk about science ideas, how they learn with their peers, solve authentic problems and come to think for themselves. Just as importantly, we have learned how teachers can support growth in these areas even under challenging circumstances.

SPEAKER: He's using energy.

SPEAKER: Ambitious Science Teaching is in part, an attempt to identify the most credible and robust research findings on teaching and learning. And then to represent this knowledge in a form that's useful for our science education community.

SPEAKER: We will give you a brief tour now, of what you would see if you visited classrooms of ambitious educators. You would see the same eight fundamental themes play out, from kindergarten through high school, as well as in the preparation of teachers for these classrooms.

SPEAKER: Theme one is that learning is oriented around complex and puzzling phenomena. Students are engaged with these over many days, as they develop explanations for processes and events that require hands-on investigations and the application of many science ideas. Here--

[CHATTER]

--Anna has her middle school students wrestle with the question of why soft drinks can be distilled into what appears to be pure water.

[CHATTER]

In a high school classroom, Bethany asks why a population of hares cycles up and down every 11 years.

[CHATTER]

In a kindergarten classroom, Michelle students wonder how something little can push something big on a playground slide. The second theme is that students' ideas and experiences are treated as resources for everyone's learning.

For example, in a discussion about ecosystems, Bethany discovers that one of her students is from Saipan, where the brown tree snake is a very destructive, invasive species. Because this student has such a deep local knowledge, of the islands and their animal population, she makes these experiences the focus of the following day's class.

SPEAKER: We said they increased because they didn't have a natural predator on this island, and they had some good food source.

SPEAKER: In Carolyn's third grade class, her students tried to explain how a singer could break a glass with just the energy from his voice. Carolyn recorded their initial theories, and students used these to imagine investigations they might do to test each of them.

[CHATTER]

Similarly, in Anna's middle school classroom--

[CHATTER]

--she posted student hypotheses about distilling soft drinks from the previous day. They spent the lesson deciding if and how they were really different from one another, and what kind of evidence would support one or the other.

[CHATTER]

In a kindergarten class, Michelle wants students to understand that they can have science ideas--

[CHATTER]

--and that such ideas don't just come out of books.

[CHATTER]

The red, yellow, and green ovals on the whiteboard get tallies marked next to them, when a student repeats someone else's idea, develops a new idea of their own or adds on to an existing idea.

[CHATTER]

The third theme is that teachers provide varied opportunities to reason through talk. Teachers create these opportunities for students to talk in every lesson. Teachers themselves have discourse moves that get young learners to lay out more of their reasoning publicly, to critique each other's ideas productively and to ask questions.

SPEAKER: [INAUDIBLE].

SPEAKER: In Sean's eighth grade classroom, he provides routine time for his students to talk to one another about science ideas.

[CHATTER]

But he's also structured how they interact, to ensure that partners listen actively to one another and that they both get a chance to contribute.

[CHATTER]

In Anna's seventh grade classroom, her students know that she'll elicit their ideas in whole group discussion. Students also know that they are expected to make their reasoning public, and not reply with a single word or phrase.

SPEAKER: [INAUDIBLE].

SPEAKER: Anna probes a student's initial thinking in everyday terms, about how a metal bar transfers heat from one end to the other.

STUDENT: When the candle is heating the metal, the metal will get hot, so it will [INAUDIBLE] and then it'll melt the wax. The metal is hot.

SPEAKER: OK, so there's certain steps to what we need to do first. Is that what you're saying, that the metal will get heated first and then it will heat the wax? OK.

SPEAKER: Extended turns at talk are rare in most science classrooms, but it is not unusual to have students in Anna's classroom explain their thinking at length.

[CHATTER]

One thing that makes enriched talk possible is a repertoire of discourse moves by the teacher. Here in a teacher education class, I am about to model how to hold a conversation with young learners. I've decided to make explicit to my pre-service teachers, the questions and follow-ups I'll use when they play the role of high school students.

I have got those three episodes in the trajectory of this discourse, the what, the how, and the why. [INAUDIBLE] top to bottom, and then also the follow-up moves that I can make here. I'm going to put them up on the board behind me, so you can just see if I use any of those.

The fourth theme is that thinking is made visible. The teacher can understand how students are reasoning, and students can see and hear the ideas of their peers when those ideas are made public.

In Bethany's sophomore biology class, she asks students to predict how a population of hares would fluctuate over time. The exercise reveals an amazing diversity of predictions, and reasons why the population would change.

[CHATTER]

Bethany has each group of students share their thinking to the whole group.

SPEAKER: Is this similar to Anthony, except for she's adding--

SPEAKER: In Michelle's kindergarten classroom, students are using a representation of a slide, and a set of science words to piece together an explanation of how something little can push something big. You can see how these scaffolds help the first boy show what he knows about the forces. The other students build on his ideas.

SPEAKER: Who can come and tell me which science word they think would go on that first red dot? Logan, what do you think? It goes there. Push, pull, nice. Pull, [INAUDIBLE]. Push up here. [INAUDIBLE]

STUDENT: Yeah.

SPEAKER: What? Why does he have so many pushes and pulls? So does it go all the way up? Logan, can you tell me why you did that push?

STUDENTS: Push, pull, push, pull, push, pull, push, pull, push, pull, push, pull, push, pull, push, pull, push, pull, push, pull, push, pull,

SPEAKER: Push, pull all the way up, is that a new idea? Yes.

[CHATTER]

Where is gravity? Where does it happen? Show me.

STUDENT: You repeat it.

SPEAKER: Oh, good. OK, so tell me why you put it down there. You can leave it. It's hard to-- OK, good.

STUDENT: Because it pulls everybody down, so you don't get blowed up.

SPEAKER: You're right, that's a new idea. Good job, OK. So gravity's always there. Gravity's here, gravity's here, gravity's all over.

[CHATTER]

SPEAKER: The science practices of modeling and evidence-based explanation are foregrounded in ambitious science teaching. Students expect to revise representations of how they think of the puzzling phenomenon over the course of a unit. Teachers always ask, how has your thinking changed and why?

[CHATTER]

Bethany's students are using what they've learned over the last few days, to think about the relationships between species at different trophic levels in an ecosystem.

[CHATTER]

But they also want to include authentically complex conditions like disease, invasive species, and climate change. In Anna's classroom, students are studying the energy story behind the distillation of a soft drink.

Their version of modeling at this early stage is to place post-it notes with ideas about what's happening at each of the four stages, before distillation to after the soft drink had boiled away. We can also hear Anna saying that she expects these models to change in response to evidence and new ideas.

SPEAKER: We are going to use those ideas you had at the beginning of class, to try to explain different parts of what happened yesterday. All the post-its you see up here are from first and second period.

So this isn't just your class, we're actually sharing our ideas across classes. So we're going to try and come up with a bunch of different reasons why this stuff is happening. We're going to post it in the room.

And as we learn more about what's going on, we might say, oh, that wasn't true. We're going to take that post-it off. Or we might put a big star on post-its that have ideas on them, that we verified with labs and readings and stuff. Or we might add more information or add post-its even.

SPEAKER: In a teacher education class, I teach several connected lessons from a unit on the gas laws. I use the interesting case of a railroad tanker car that mysteriously collapsed after being steam cleaned.

After eliciting initial ideas, I have my students model what they think happened, using a before, during, and after template. I then have my students engage in a number of investigations, and change their models appropriately.

[CHATTER]

STUDENT: Oh, yeah. Oh, yeah.

STUDENT: Wow, yeah.

STUDENT: Oh my gosh, it's so little.

SPEAKER: But let's see what happens. Here we use post-it notes to add, revise or question our initial ideas. The sixth theme is the use of specialized tools to support talk and writing. Because expectations for students understanding and interaction with one another are so high, teachers use a variety of tools and scaffolds to support this work.

[CHATTER]

In Bethany's classroom, she supports student writing by providing sentence frames for how they can describe a change to their current ecosystem models.

SPEAKER: OK, so if you add something, you're going to describe it on this light green post-it note, and there's some kinds of sentence starters you might say, like we added blah, blah to our model because. And then you're going to say evidence either from an activity or reading discussions you've had or another group's hypothesis.

SPEAKER: Another scaffold for writing is a claim, evidence, reasoning tool that students use. It also provides sentence frames and a visual way to organize how they link evidence with claims.

One scaffold for a whole class discussion is a set of student-created posters for describing how they might add on to one another's ideas, ask for clarification of a statement or civilly disagree with the classmate. The seventh theme is that activities build towards cumulative understandings.

All the investigations and readings build towards more sophisticated understandings of the puzzling event that is anchoring the unit. Students understand the purpose of each day's activities, and teachers regularly ask, how does the work we've done today help us see the bigger picture?

In the teacher education class, I use what's called a summary table, a representation of our collective thinking that records not just what we learned from an activity, but in this case, how it helps us figure out the imploding railroad tanker car.

I demonstrate this after an investigation involving the compression of marshmallows inside of a syringe. So how does this help us think about the tanker? What does this got to do at all with the tanker? We're working with a marshmallow.

STUDENT: Well, our group talked about how when we are thinking that we are increasing the pressure inside the syringe, we can watch the marshmallow because it's a squishy material, slowly compresses, the pressure increases. But we think that with if we compare it to the tanker, it's such a rigid material [INAUDIBLE].

SPEAKER: [INAUDIBLE] to do this, I want you to write [INAUDIBLE].

SPEAKER: Here, Bethany uses a variation of the summary table with her high school sophomores.

SPEAKER: [INAUDIBLE].

SPEAKER: They're trying to figure out if the latest activities they've done influence hypotheses that they had developed about the ecosystem.

[CHATTER]

In this kindergarten classroom, Michelle has her students use a balls and ramps activity to deepen their understanding of force, action, and reaction. To help them understand the bigger picture of who can push who on a slide.

SPEAKER: You guys measure this one. OK, so it looks like the bigger ball pushed the cup farther, but that's not the end of the story you guys. Are you ready to be scientists?

STUDENTS: Yeah.

SPEAKER: OK, I'm going to write this in. It says, the blank ball pushed the cup farther because it has?

STUDENTS: [INAUDIBLE] force.

SPEAKER: More? More strength, more force.

[CHATTER].

SPEAKER: In this snippet, we can see on the wall behind Michelle, that she had strategically placed the images of the balls and ramps just next to the image of the slide.

SPEAKER: [INAUDIBLE].

SPEAKER: Our final theme is that everyone is helped to participate, The teacher constantly problem solves about who is not taking part, who is quiet in our conversation today and why. Do they need encouragement, scaffolding, language assistance, to be partnered with more helpful peers? These are the images of ambitious science teaching.

The teachers we've shown here are constantly experimenting with their practice. They are striving towards rigorous and equitable experiences for their students. No one has arrived yet, and there is no right way to do this work.

Hopefully, some of what you've seen is familiar or compelling, and can serve as an entry point into conversations with your own colleagues about professional learning. In the videos that follow, we show four core sets of teaching practices.

These practices all work together to make learning cumulative and coherent for students, but they serve another role too. The practices serve as a common language for any group of educators that wants to improve instruction together.

The goal is to help us communicate with one another, as we work on our teaching. The ultimate goal if we can dream a little bit, is to support widespread change in how science is taught, to help make extraordinary instruction commonplace in our schools.

[MUSIC PLAYING]