Bridging Skills and Content: Connect the Practices and Recurring Themes and Concepts With Discourse

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Presentation Slideshow

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Versatile Lessons for Versatile Classrooms™

Three-Dimensional (3D) Learning Trail in Practice A Segments

The 2021 Science TEKS informs the 3D learning process across two new strands:

- Scientific and Engineering Practices (SEPs) and
- Recurring Themes and Concepts (RTCs).

So, what are the implications for Science instruction?

- The overall impact of the new Science TEKS standards is a shift in pedagogy to mirror inquiry-based learning ignited by exploration to explanation.
- Emphasis is on what 3D learning is and how it is implemented. This is achieved by the following two objectives:

    1. Strategically and systematically integrate scientific and engineering practices (SEPs), recurring themes and concepts (RTCs), and grade-level content as outlined in the TEKS.
    2. Anchor the learning in phenomena and engineering problems as the key lever for driving learning and student mastery of content knowledge and skills.

The Practice A segment of each TREK moves students through a series of points along the 3D learning trail as they work to **master content through the exploration of model investigations**. The TEKS knowledge and skills (KS) as well as the student expectations for the SEPs and RTCs are noted.

Point 1 Anchor Learning in Phenomena (KS 5.1)

+ Observe and/or read information about phenomena (SEP TEKS 5.1A)
+ Find patterns (RTC TEKS 5.5A)
+ Ask questions (SEP TEKS 5.1A)
+ Develop explanations about phenomena (SEP TEKS 5.3A) using systems models (SEP TEKS 5.1G and RTC TEKS 5.5D) and/or mathematical calculations (SEP TEKS 5.2C)
    + Identify components of the system model
    + Use connections between parts of the system to describe and make predictions about the phenomena
    + Identify and describe a scientific cause
    + Determine how to test the model (SEP TEKS 5.1B)

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Point 2 — Plan and Conduct Investigations (KS 5.1)

+ Determine how to test the model (SEP TEKS 5.1B)
+ Establish the cause (RTC TEKS 5.5B)
+ Identify variables
+ Develop a procedure
+ Identify tools and materials
+ Demonstrate safe practices and use safety equipment (SEP TEKS 5.1C)
+ Use tools to observe, measure, test and analyze information (SEP TEKS 5.1D)
+ Collect evidence (SEP TEKS 5.1E)
+ Construct organizers used to collect data (SEP TEKS 5.1F)

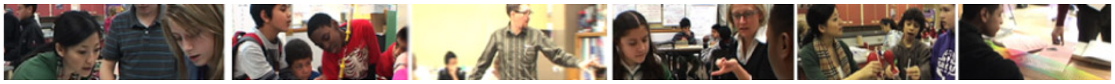
Point 3 — Analyze and Interpret Data (KS 5.2)

+ Analyze data (SEP TEKS 5.2B)
    + Identify significant features, patterns or sources of error (RTC TEKS 5.5A)
    + Use mathematical calculations (SEP TEKS 5.2C)
+ Identify advantages and limitations of models (SEP TEKS 5.2A)
+ Evaluate experimental designs (SEP TEKS 5.2D)

Point 4 — Develop and Communicate Explanations and Findings (KS 5.3)

+ Claim-Evidence-Reasoning model (SEP TEKS 5.3A)
+ Communicate explanations in a variety of settings and formats (SEP TEKS 5.3B)
+ Listen to others' explanations (SEP TEKS 5.3C)
+ Engage in respectful scientific discussion (SEP TEKS 5.3C)

A Discourse Primer for Science Teachers



This chapter is an introduction to talk in science classrooms. Talk is a natural activity that we all engage in. As part of our daily lives we use words in various combinations to create speech, and with speech we get work done such as asking questions, providing information, and explaining ideas to one another. But discourse in classrooms can be quite unlike that in our everyday life—there are unfamiliar words that get used, different kinds of work that need to get done with speech (comparing two science explanations, arguing with evidence, critiquing a model, etc.), and rules for participating that aren't always clear. This kind of talk can feel unnatural. Because of this, teachers who want to facilitate productive forms of science discourse with students have to intentionally design opportunities for students to try out new ways with words, and support them in a variety of ways as they learn to "talk science."

For you and your colleagues to experiment with discourse in your classrooms it helps to develop a common vocabulary about talk itself. With just a few basics, you can begin to view your classroom interactions through an entirely different lens. Together you can try out new strategies, debrief them, and advance your practice.

Talk as an opportunity to think: A visit to two classrooms

Here's a very simple kind of logic about talk in classrooms. We start with learning—*learning is a result of thinking*. Certain forms of classroom talk stimulate thinking. Therefore the orchestration of productive discourse in classrooms presents opportunities for students to learn. The key here is discerning productive from unproductive talk. We'll take a look now at two examples of discourse routines, to get a feel for what productive talk is.

Consider a high school laboratory activity that begins with the teacher hanging a mass from a spring-scale at the front of the classroom. The scale reads "1 kilogram." He then produces a large bell jar which he places over the entire scale and attaches the jar to a vacuum pump. "Can anyone share their thinking about what the scale might read if I pump all the air out? Let's take a minute to generate some hypotheses." After a period of quiet thinking, students begin to offer a few thoughts.

> *Jaden*: I'd say it would weigh less—
> *Teacher*: Can you say more about that?
> *Jaden*: Because before you put the jar on top, the air is pushing down on it—the air weighs something, so it's the weight of the thing plus the weight of air.

Teacher: And when you pull the air out?
Jaden: It's not pushing down anymore so it weighs just a little bit less.
Teacher: Mm-hmm. [Waits in silence]. Anyone else want to add?
Helena: Well, air weighs something, but air I think is pushing on all sides of the thing, not just the top…
Jaden: Like water, if you're under water in a pool.
Helena: Yeah.
Teacher: Wait, Jaden are you changing your mind? How is your pool example like Helena's claim?
Jaden: So if you are under water, maybe you can feel pressure from all sides?
Marta: So it's like a submarine—it can get crushed if it goes too deep, crushed on all sides, so that's evidence—I can look it up…
Teacher: Evidence of what, Marta?
Marta: Water, the air is like an ocean, pushing on all sides, so we get that pressure on all sides all the time.
Teacher: OK, Marta, so it sounds like you've claimed that air has the same effect that water does, it exerts pressure on all sides. Does that mean the mass would weigh the same without air in the bell jar? More? Less?
Marta: The same? Now I'm not sure.

As this lesson continues the teacher poses questions that probe the mental models his students are beginning with, assessing how coherent these models are, how generalizable, and whether they can use each other's ideas as resources (e.g. the submarine model). He must decide who has "pieces" of the scientific explanation and how to help students put these partial understandings together for themselves. In addition to all this, he monitors whether students are following classroom norms for civil conversation and the degree of involvement, puzzlement, or frustration of individual students. These young learners spend the majority of time reasoning about science ideas in whole class discussion and in small group conversations, nearly every day of the school year.

Of course this teacher could tell the students what the "answer" is, but this would not provide any opportunities for students to think—resulting in no changes to their mental architecture. And students would dutifully reproduce what the teacher told them on the next test, without understanding what they were saying.

The culture of talk in this physics classroom is conducive to learning, but this kind of social/intellectual activity is rare in schools. Discourse in most science classrooms is restricted to very teacher-controlled, low-level exchanges with students. The most common pattern of talk in these cases is referred to as "I-R-E." This stands for *initiation-response-evaluation*. It represents discourse that is *not* helpful for student thinking, and is actually used by teachers to constrain students' talk. The *initiation* is typically a question (by the teacher) that has a known, "correct" response, and requires only recall or a simple calculation on the part of the student. The *response* (by the student) is usually a one or two word phrase, offered by the first person to raise his/her hand. The *evaluation* (by the teacher) is a comment signaling that the student is either right or wrong. An example from a middle school earth science classroom would be:

> *Teacher*: What are the three different kinds of rocks?
> *Student*: Sedimentary, metamorphic, and igneous?
> *Teacher*: Good!

Later in this lesson the teacher uses a "fill in the blank" or "read my mind" speech pattern, but it still qualifies as I-R-E. An example would be:

> *Teacher*: So igneous rocks come from…? (with rising intonation in the voice)
> *Student 1*: Volcanoes?
> *Teacher*: Noooo…(again the rising intonation of voice)
> *Student 2*: Magma?
> *Teacher:* Almost…can anyone help?
> *Student 3*: Lava?
> *Teacher*: That's right.

There are many variations on this theme, but in each case, answers are valued over thinking. Students may give partial responses and the teacher may have other students fill in what is missing from an initial student utterance. Some teachers are more polite than others about incorrect answers, some are more terse. This sort of dialogue can become a running quiz that puts most students on edge, allows only certain kinds of students to participate, focuses only on the lowest levels of thinking, and in the process, drastically undershoots what young learners are capable of. Teachers using I-R-E typically cherry-pick the right answers from a few eager kids and then assume everyone has a shared understanding. The teacher then moves forward under this faulty assumption.

The "guess-what's-in-my-head" dialogue is so common that it's been called the default pattern of talk in schools. This type of discourse is also one of the most difficult for students with different cultural and linguistic backgrounds.

We write about I-R-E here because, as we mentioned, it is so common in schools. We have seen entire 50-minute class periods in which students have endured one I-R-E sequence after another. Sometimes students are asked to respond to I-R-E questions in unison—giving a choral response—but this routine has little learning value. If you recognize this form of talk in your own classroom, you should make every effort to figure out why you are using it and how you can shift to more productive forms of discourse. This primer, as you will see, is filled with alternatives to I-R-E.

As we share examples of productive talk—in elementary through high school classrooms—we should warn you that *much of why this classroom talk works so well is invisible*. For example, setting the stage for students to participate actually happens early in the school year. In September the high school physics teacher we mentioned spent a great deal of time and patience trying to model for students how to comment on one another's ideas. He set up norms to make all students feel safe, to offer ideas, and gave regular feedback to students on how they were using talk. Much of the discourse that appeared so natural late in the year was set up by many months of clumsy attempts by students to interact with each other. It was marked by uncomfortable silences and by the teacher being really explicit with students about "what counts" as productive conversations.

How does one develop expertise like this? How does one lay the groundwork with students? For any teacher, there are principles of classroom discourse that can be studied, rehearsed, and refined. Expertise is simply a matter of deliberate practice. The following sections of this document (see at right) will acquaint you with some fundamental ideas about productive discourse in classrooms. They can serve as tools to help you analyze the discourse of other teachers and to begin innovating in your own classroom.

Topics

Why is talk so important for learning?

Talk is a form of thinking. Research in linguistics and social psychology show that people do not engage in talk merely to communicate something they already know. Rather, to prepare to talk means that one has to formulate what might be relevant to say, but these mental formulations are never very explicit until one begins speaking. In this way, thought is often constructed simultaneously with speech. Speech is a vehicle for all forms of reasoning: comparing ideas, elaborating on them, critiquing them, relating them to everyday experiences, the list goes on and on. Students who get practice at this become better learners, both individually and as a class. It is sobering to think that in many classrooms, students sit, nearly silent, as their teachers do all the talking—and that this experience may literally go on for years.

Student talk makes their thinking public. When students engage in conversations about science they reveal a lot about their conceptual understandings, their beliefs about how science works, and how they are making sense of new ideas. The richer and more frequent the contributions by students, the clearer their state of understanding becomes to the teacher. Speech as a record of thought allows the teacher to address gaps in student thinking, to design specific activities to advance the reasoning of students, and to build on the partial understandings they bring to class.

Students' ideas are resources for others. Not only does the teacher benefit from hearing a student's ideas, everyone in the classroom gets an opportunity to hear how another person thinks. Students benefit from understanding how others frame problems, build upon the ideas of peers, disagree with one another, and construct explanations. An everyday episode or puzzlement that is described by a student can spark new connections or be used as an example by others in their efforts to understand. Even if students offer ideas that are technically incorrect or fragmented, the rest of the class can have access to examples of civil disagreement and the socially appropriate challenging of the claims of others. Productive and public talk then, is a multiplier for usable intellectual resources.

A talk culture helps us understand who is silent. Unlike a traditional science classroom in which students are expected to sit and listen most of the time, a discourse rich classroom allows the teacher to see who is not participating. Students who are not talking may indeed be benefitting from hearing the thoughts of others, but they may also feel marginalized or intimidated. These are often students whose cultural or linguistic backgrounds are different from the majority. In a talk-rich environment, reluctant students are more easily identified, but that does not solve the problem. Teachers have to find ways to diagnose why students are quiet, and then consider appropriate strategies to invite or enable their participation. Such ideas will become clearer to you as you read this primer and learn more about discourse.

Science talk is a specialized language. Talk apprentices students into the discipline of science. As we mentioned earlier, much of science talk is unnatural for learners. When teachers model certain forms of discourse and give students opportunities to try out science-specific forms of talk, it can help learners build identities as knowers of the natural world. What are the discipline-specific forms of talk? Examples are: hypothesizing, debating what counts as a good explanation, arguing with evidence, using language about setting up credible experiments, referring to patterns in data, deciding how to revise a model, and more. These examples, by the way, are all tied to the science practices listed in the *Next Generation Science Standards*. The emphasis on science practices in the past has been characterized as "hands-on" work. We should be re-thinking this. Science practices should be thought of as using specific ways of reasoning and talk that guide the material work and make it meaningful; this is how core work of science done.

Expertise is simply a matter of deliberate practice

Maintaining a safe classroom for student conversation

A safe classroom is one in which students feel that they will not have their ideas ridiculed, and that the teacher and peers will value what they have to say. Productive conversations require students to take risks in public—to hypothesize about things they are only partially familiar with, to comment on the ideas of classmates, or to ask questions that may reveal a lack of understanding. Because of this, the most basic pre-requite for productive conversations is that all students *feel safe* in speaking publicly.

Classrooms should have norms for civil discussions that are developed—with help from your students—from the first day of school, that are explicitly modeled by the teacher (i.e. the teacher "names" the norm as she/he uses it) and reinforced on a regular basis. Here are some samples of these norms—there are many possibilities:

- Anyone can ask questions if they don't understand an idea that is being talked about

- We (students and teacher) can critique ideas of others, but personal attacks are out of bounds
- Don't talk over your classmates
- The teacher will give "think time" before asking for students' ideas
- In small group work, everyone will contribute to the conversations

It is helpful to re-visit these norms periodically, asking your students: "How did we do today in our discussion? What talk moves do we need to work on?"

Some students don't participate because they are so unfamiliar with critiquing the ideas of others or adding onto a peer's comments. They don't know how to publicly disagree and some students even feel uncomfortable agreeing with others in class.

For these reasons some of our teachers have developed, with students, a list of sentence frames (structures for student talk) to help them accomplish what seems unnatural. We share one tool above. Are these tools perfect? No. Do they work? Yes, if you ask students to rehearse this kind of talk. It's deliberate practice—for students.

Pre-thinking the goals of classroom conversations: 4 categories

One of the big reasons teachers flounder in the middle of classroom conversations is because they haven't imagined what the specific goals of the conversation are. It is vital to pre-think where you'd like to *end up* at the finish of a conversation. You want students to get some intellectual work done—but what kind of work is possible? Do you want students to develop a list of initial ideas about how a scientific phenomenon occurs? Do you want them to make sense of an activity? Do you want them to critique an explanatory model?

These considerations prime you to hear certain types of talk from students and prepare you to respond without having to improvise every word you say. We'll start by considering *four high-level goals for talk* that we use to organize our thinking—each uses a different set-up and instructional moves (in following sections) to accomplish their purpose:

- *Eliciting students' initial scientific hypotheses in order to plan for further instruction*. The goal of this discourse is to draw out students' understandings of a phenomenon (e.g. a bicycle rusting in the backyard) that is related to an important scientific idea (in this case chemical change or conservation of mass). After the lesson we analyze students' ways of talking about it in order to adapt upcoming learning experiences.
- *Making sense of data/information*. The goal here is to help students recognize patterns in data, critique the quality of data, and to propose why these patterns exist. What, for example, is going on at the unobservable level that explains our observations?
- *Connecting activities with big scientific ideas*. The goal of this practice is to combine data-collection activities with readings and conversation in order to advance students' understanding of a broader natural phenomenon. This conversation is different from the previous one, in that students are not trying to explain the outcome of an activity, but to relate the activity to a bigger science idea or puzzle that the unit is framed around.
- *Pressing students for evidence-based explanations*. This discourse is designed to happen near the end of a unit, but elements of this conversation can also happen any time the teacher is trying to get students to talk about evidence. The goal of this discourse is to assist students in using multiple forms of evidence, gathered during a unit, to construct comprehensive explanations for a phenomenon that has been the focus of the unit.

If you are clear about what kinds of talk you want to foster—even to the point of having different kinds of names for these conversations—it becomes easier for you to anticipate student contributions and to plan how students can become meaningfully involved in the talk. In the following section we have specific examples of questions that would be appropriate to start and sustain these conversations.

Cognitive demand of questions and tasks

Remember our simple logic model that starts with "Learning is the outcome of thinking?" Well, thinking has a lot to do with the types of questions that get asked in class. Questions and tasks in classrooms can be thought of in terms of what they require learners to do intellectually. These can roughly be divided into those with *low-cognitive demand* and *high-cognitive demand*.

Lower cognitive demand questions/tasks

These typically focus on either memorization (recall), on vocabulary-level understanding only, or on procedural tasks that ask students to follow prescribed steps or plug numbers into formulae. You can actually tell low cognitive demand questions and tasks because they have a "right answer" and can be expressed in a phrase or a number. There is nothing inherently wrong about low cognitive demand questions or tasks. Occasionally you do need to check students' basic level understandings.

Some low cognitive demand tasks can be challenging for students to answer (for example memorizing the entire periodic table), but they don't involve much intellectual work. They don't ask students to do anything *with* ideas. These tasks produce the *illusion of rigor*. If these become the default mode of your instruction, your students will only rise to the level of what you are asking of them.

Higher cognitive demand questions/tasks

These typically focus on *sense-making* by the students. High cognitive demand questions or tasks ask students to *do something with* ideas (this is what defines reasoning). These questions/tasks demand more intellectual work and may not have discrete answers—this is why they are often referred to as "authentic questions or tasks." They are much like what professionals deal with in everyday life. You can for example ask students to unpack an idea in their own words, give an example of some science principle, compare or contrast ideas, solve non-routine problems, justify an explanation, use evidence to support a claim—these are just some of many possibilities. The following are some comparisons between low and high cognitive demand questions.

Asking students to work with information	
Lower Cognitive Demand	Higher Cognitive Demand
Recalling and reproducing ideas	***Processing ideas***
• Task/question requires only the recall of previously learned material—sometimes a one-word or one-phrase response. In one physics textbook, a question is posed "What is meant by free-fall?" In another section, "What two units of measurement are necessary for describing speed?" In biology, a student may be asked to	• Tasks or questions require students to use (not regurgitate) ideas and information in ways that expand understanding, such as to: -create or interpret representations of information - make connections between different kinds of representations of information (e.g. as represented in visual diagrams, graphs, drawings, analogies, manipulatives, symbols, problem situations) - recognize and use evidence to support explanatory claims - distinguish between "what", "how", and "why" explanations - create and critique explanatory models - apply knowledge in contexts different from those previously

"Define natural selection." • Task/question involves reproducing an explanation previously seen in written material or given by the teacher. An example here is: "Where is DNA stored in a cell?" Another example: "What 2 particles account for almost all of an atom's mass?"	discussed in class An example may be: "A frog's heart has 3 chambers (2 atria and 1 ventricle), and their blood flows from the right atrium, to the ventricle, to the lungs, to the left atrium, and then back to the same ventricle. Because of this structure, why might it be possible for humans to have more endurance than a frog?" An example from physics: "When riding in a car, you can roll down the window and hold your hand like a flat wing in the air. If you can lightly tilt the front edge of your hand up you'll feel your hand lifting. How can Newton's Laws of Motion help you to explain the lifting effect? Are these laws enough for a complete explanation or do you need other ideas?"

Questions about classroom activities

Lower Cognitive Demand	Higher Cognitive Demand
Failing to connect activities to ideas • Task is like a recipe to follow; it leaves little ambiguity about what needs to be done and how to do it. Many lab activities, for example, are often made into robotic exercises in following directions. Usually it is good to be explicit about what you want students to do in a task, but students should be given the opportunity to exercise judgment rather than rotely follow procedures. • Sometimes questions/tasks involve manipulating numbers and symbols. Again, these are not bad questions, unless they become the staples of your instruction. An example in physics: "What is the acceleration of a vehicle that changes its velocity from 100km/hr to a dead stop in 10 seconds?" A chemistry example: "Please balance the following equation: Zn+ HCl -> $ZnCl_2$ + H_2"	***Connecting activity with ideas*** • Task requires some thinking: although may use a procedure, it cannot be followed mindlessly. Students need to engage with conceptual ideas (understand what they mean) in order to successfully complete the task. • Task solution not self-evident to student, due to nature of solution process required. An example in chemistry: "You and your friend like to cook. Your friend thinks that pure water (H_2O) will boil faster than salt water. You disagree. Who is right? Design an experiment to test your respective hypotheses about water boiling, and provide evidence you could use to support your claims.

Asking for explanations

Lower Cognitive Demand	Higher Cognitive Demand
Seeking only a "what" explanation • Task or question requires only a "what" explanation of the target phenomenon, not "how" or "why" explanations. A "what" explanation is *not an explanation at all*— it is merely a detailed description of something observed or read about. For example, a "what" explanation in chemistry might be "Explain what the differences are between acids and bases." Or "Explain what happened when we mixed baking soda and vinegar." ***Hiding behind vocabulary*** • In some cases a question is phrased as a "why" but	***Seeking "why" explanations*:** • Task/question requires a why explanation. By a "why" explanation, we mean that the student can use evidence, information, and logic to tell a *causal story* for the target phenomenon. This causal story *always involves unseen, underlying events and processes that have to be connected in a logical way to explain observable events*. This causal story is often referred to as an *explanatory model* because it can be used to explain a whole range of phenomena in the natural world. An example from biology might be: "The bird flu (a virus found in birds) has been in the news recently because

the teacher is satisfied when student gives a vocabulary term as the answer.

An example here is: "Why do arctic fox have white fur?" Student answer: "Because of evolution."

Another example is: "Why does dye disperse faster in warm water than in cold water?" Student answer: "Because of kinetic molecular motion."

Students may be able to reproduce or recognize such brief responses, but they should be pressed further: "What do you mean by that? Can you explain?"

several people have died from it. However, the infected people did not transmit the bird flu to any other people. Using your understanding of evolution, please explain a) Why people can become ill from a virus that infects birds, and b) Is it possible for someone infected with the bird flu to transmit the virus to another person? If so, why?"

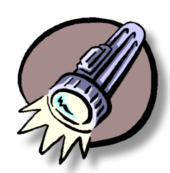
From earth science: "Why are solar eclipses so rare?"

Another type of high cognitive demand question that deserves its own category is the "what-if" question, otherwise known as a thought experiment. Thought experiments are hypothetical situations that allow students to test a claim by playing out the consequences of an imagined situation. To do this, students must "run a model" in their minds but also share with peers what they are thinking. For example, in a unit on ecosystems, students might claim that if two organisms occupy the same niche in the system, it would not affect other populations if one of the organisms went extinct. The thought experiment would be presenting an ecosystem with two organisms that appear to inhabit the same niche and ask: "What if we removed this one? What would happen? Let's play this out over time." Another example from upper elementary earth science would be the question: "If we were able to suddenly turn off the gravity of the earth, what effects would that have on the moon?"

Discourse moves

By *discourse moves*, we mean the specific conversational turns that teachers use to orchestrate the development of ideas in the classroom. These moves can be used any time, such as in 5-minute warm-ups at the start of class, in whole class conversations, or when the teacher talks with students in small groups. Teachers can also encourage students to use these moves with each other. Discourse moves can serve a range of purposes. They can elicit student reasoning, model how one thinks, encourage all students to participate, emphasize key ideas, and ultimately help students appropriate scientific discourse themselves. Here are five categories of moves that skilled teachers use—probing, pressing, re-voicing, encouraging peer-to-peer talk, and putting an idea on hold.

Probing



Probing questions or prompts get students to *make public* more of their thinking. This is perhaps the most important function of classroom conversation. Usually these questions or prompts are preceded by some activity/situation/reading/video about which students can share initial ideas. In an elementary classroom, for example, one of our teachers showed a video of a singer breaking a glass with just the energy from his voice. She used three common probes with her students:

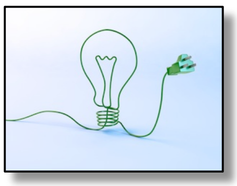
- What experiences have you had with [really loud sounds]?
- What did you think was going to happen in this [video, situation, demo]?
- What did you notice happening here?

Follow-up prompts are just as important as the original question:

- Can you tell me more about that…
- Can you explain/describe it in a different way?
- What do you mean by that?

When probing, the teacher is not supposed to be evaluating student responses, but rather to get as much of everyone's experiences and initial ideas into the conversational space as possible.

Pressing



There are times when a teacher must prompt students to reason further (out loud) about something they've just been talking about. This is "pressing." Pressing students is very different from eliciting their ideas and experiences (i.e. different from probing). Pressing means that the teacher does not allow students to offer shortcut responses, unsupported claims, or respond with "you know." When a student offers an initial idea, the teacher for example can ask in return: "Why do you think that?", "Isn't that a contradiction to what you said earlier?", or "What evidence do you have for that claim?" These are reasonable ways of holding students accountable for thinking. You can tell when you are pressing young learners because they will often visibly squirm when you won't give up on their thinking. Pressing can be done in whole class episodes or as the teacher visits groups of students around the room. We note here that it is possible to press the whole class to reason further about a statement someone has made. Here are some types of pressing moves by teachers:

Asking for examples

- Can you give an example?
- Can you think of a case where this holds true?

Requests to "fill out" an explanation

- Sounds like you have the start of an explanation [repeats students' partial claim or explanation], and you have the end, but isn't there something that happens in the middle?

Press for consistency with other ideas

- Does your claim fit with the data we have?
- Does your explanation fit with other science ideas, like [state science concept]?
- But do we know if [express known science ideas] is consistent with what you are saying?

Asking for evidence or justification

- What makes you think that?
- What evidence do you have?
- How does that idea support your claim?
- Do you think that is strong evidence?

Asking how one could test a claim or hypothesis.
Occasionally a student will state a claim that you might recognize as being testable in a simple way. So, with the appropriate degree of support, you can ask the student, or the whole class:

- That's an interesting idea, is there a way we could possibly test it to see if it's true?
- What might we need to do that?
- What would make a fair test?

An example here is from one of our middle school lessons on cellular respiration. A group of students had just completed an activity in which they mixed yeast with some sugar and warm water in a flask. They then affixed a balloon on top of the flask and watched it inflate over a 30-minute period. Some students explained to the teacher that the balloon was inflating because of warm air in the flask rising. Another group of students thought that the yeast was coming alive and eating the sugar, then giving off carbon dioxide. The teacher, at the end of class, asked students: "Is there a way to test one or both of these hypotheses?" "Is there a way to test to see if one of the hypotheses is *not* true?" "What equipment would we need and what kind of data would be collect?"

As you can imagine, knowing who and when to press requires that you know your students and that you've established a safe classroom environment for these conversations. You will need extra patience with this conversational expectation in the classroom, since "press" is something that very few kids experience in their other classes, or in their everyday lives.

Re-voicing

Re-voicing means that the teacher paraphrases and re-broadcasts what a student has said, in order to enhance the clarity of that contribution for other students. Revoicing is usually done in the context of whole class discussion. Here are some examples of re-voicing moves and the reasons you would use them:

Re-voicing to mark a students' idea: Here's the situation; a student has taken a long-ish turn at talk to express an idea, a disagreement, or some experience she/he has had relevant to the science. The teacher recognizes that one part of this lengthy response is particularly important as a resource for the rest of the class to reason about. This is when a teacher selects that specific portion of students' comments to restate. It may sometimes be only a word the student has said, but it can be a full hypothesis, observation, or a question.

Here is a common sentence stem a teacher might use after a student has given a legitimate but long and occasionally disconnected interpretation of a classroom demonstration: “So [name of student], what I hear you saying is that [heat has something to do with the motion of the molecules of water in our food dye demonstration]? Am I interpreting that correctly?” This discourse move is also used when there are a number of ideas “flying around the room” that could confuse students, or that divert from the main idea that the class is working on.

Re-voicing to repair how an idea is expressed: This is a teacher’s re-statement of a student contribution in which the teacher judiciously interprets one aspect of an otherwise valid statement. This is done to prevent confusion by students when such statements might otherwise be taken without comment by the teachers. This does not mean the teacher “corrects” statements on a routine basis or evaluates them overtly, but it does mean that clarifications are made in a sensitive way. A sentence starter here might be “I understand your explanation, but did you mean to say ____?”

Re-voicing to connect students’ everyday language with academic language: This move is also to be used judiciously. Students need to hear how some forms of everyday language are connected with scientific language. Scientific language is valuable because it allows students to think in conceptual terms about ideas, and because it allows a common reference to talk about scientific practices (i.e. what counts as an “explanation”, or what counts as a “model”). An example here might be:

“So when you talk about acceleration, you usually mean to speed up, like you do when you press the gas on a car. Scientists though use that term in a different way—to mean any change in speed or direction.”

Another kind of connection between everyday and scientific (or academic) language is when a student uses an everyday term and the teacher re-voices by substituting a scientific term. For example, substituting “convection” for a student’s description of “warm air rising while cold air sinks.” The teacher here, however, must take care to maintain the students’ ownership of that idea.

Prompting peer-to-peer talk

Productive conversations are not only about teachers’ questions, they are also about *students’ questions* and how the teacher *helps students talk to one another* using the language and rhetoric of science. One long-term goal you should have regarding classroom conversations is that eventually your students should take over some of the responsibilities of guiding the discourse. The difference between the first and last week of school should be that, by the end of the year, your students have begun to ask the questions that *you* asked earlier and that your students are doing the probing, the comparing of ideas and the critiquing of peers’ ideas. Your students should be developing the civility needed to elaborate on and critique the ideas of others in a public setting—without you acting as an intermediary between every turn of talk.

To start this process, you need to tell students explicitly that you want them to address each other's ideas. Also, you should regularly provide responses to students that you want them to say to each other. Here are example sentence-frames, some of these can even be put on cards that students use in small groups:

Worth noting: You may literally have to turn away from your students to force them to address one another with their comments.

- Can anyone add to ______'s idea?
- Can anyone restate what ______ has said using their own words?
- What is the difference between what you've said and what _____ has said?
- Does your idea make you question something that _____ has said?
- Do you agree with what ____ said? Or perhaps part of it?
- So, _______, it sounds like your claim is _______ and one piece of evidence is ______. But _____ has this other piece of evidence which conflicts with yours, what do you think?

Developing peer-to-peer talk is difficult work that will take weeks or months of encouragement. Most teachers experienced in classroom discourse look for students to begin engaging with one another after about three months. Yes, that's a long time, so persistence is the key.

Putting an idea "on hold"

In the enthusiasm of whole class discussions, students often make statements that can be off-topic, or that are better addressed later on. In these cases, teachers need polite ways of acknowledging the students' contributions, while marking it as something that is not going to be talked about at this point. A teacher might say: "That's an interesting idea, and it is something that we will talk about tomorrow, but for now…" or "I like your thinking, but let's hold on to that thought…"

Caution: Many of our teachers have used this conversational move to avoid really interesting and relevant questions by students. Do *not* use this strategy to suppress kids who want to explore the boundaries of the lesson!

Some teachers have a section of their wall space devoted to genuine questions or comments that students have which may not be the focus on the current lesson. This has been called the "Parking Lot", and it signals to students that their ideas have value, but may not fit the current discussion.

Managing silence and time to think

Using wait time

During whole class discussion, students need time to think. Not everyone can spontaneously interpret what a teacher's question means and respond to it within a couple of seconds. Rapid fire questioning privileges those few kids who have mastered English, who are familiar with the "game of school," who can anticipate the types of questions the teacher will ask, and who can recall facts easily. The majority of kids, however, are silenced by this inequitable type of discourse.

One way to make conversations more equitable is to pay attention to *wait time*. This is the amount of time between when a teacher poses a question, and when the teacher either calls on a student, rephrases the question, gives a hint, or answers the question himself or herself—it is essentially the amount of time the teacher gives the students to think. Research has shown that the wait time teachers give students is remarkably short. Believe it or not, the average wait time for most teachers is approximately *one second*. This is because teachers are almost immediately uncomfortable with silence in a classroom conversation, and seek to fill the void with a student's voice, or their own. Not surprisingly, short wait time by teachers is associated with the I-R-E pattern of discourse. This same research has shown that when wait time is kept short, only a small minority of kids respond, and their responses are very brief.

Some teachers, however, have purposely lengthened their wait time to 5, 10, or 20 seconds, to give all kids time to think. In these classrooms, a *far greater percentage* of kids responded to the teachers' questions, and the responses were *longer and more thoughtful*. Wait time works best when the cognitive demand of questions is at a medium or high level. Extending wait time is one of the simplest but most effective ways to encourage equitable and higher-quality participation in classroom discourse.

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Think-pair-share

There are other strategies to give all kids time to think before joining the conversation. *Think-pair-share* is a move where a teacher poses a question, then asks students to consider silently how to respond for about 30 seconds, then join with a peer to compare their responses, then return to the whole class conversation to share their ideas. A request for think-pair-share might sound like this: "We've all agreed that air is made up different types of gasses. Oxygen is one example we're familiar with. What I'd like you to do is take a minute by yourself and write down another example of a gas that you think makes up the air around us. If you can think of more than one, that's great." [After 60 seconds…] "Now I'd like you to pair up with a partner and share what you have. Then together, pick one of your examples and talk about what convinces you that this gas is really in our air."

An even simpler way to give kids time to respond is to pose a question, request that everyone keep their hands down for 30 seconds, then ask for responses after that.

Hearing crickets

Often when teachers initiate whole class discussion, they'll pose a question but students will sit there in silence (i.e. it's quiet enough that you can hear the crickets outside). Even for experienced teachers who want a highly discursive classroom, "hearing crickets" happens from time to time. Just as teachers must manage talk, they also have to manage these uncomfortable moments. One response is to use variations of the think-pair-share we've previously mentioned. But if you think your original question is really inaccessible to students, another option is to "walk the question back" just a bit. This means to quickly ask yourself, "Should I reduce the difficulty by having student focus on just one part of the question?" "Should I first ask about some concrete aspect of the science (to orient them) before asking about abstractions?" "Should I give an example of a response?" "Should I be explicit about what to focus on in wrestling with the question?" "Have I actually asked more than one question at a time and need to re-phrase as a single question?"

If we use the previous example of asking about gasses in the air, imagine this was inaccessible and that you needed to use the strategies above; how would you "walk that task back" just a bit?

If you get silence from students frequently, this is actually a great opportunity to collect data on your own discourse practices. You can record the question that results in blank stares and the situation in which you offered the question. Trends will emerge in the data. You might find that students can't hypothesize about generic situations (like weather systems described in the abstract) but they can more readily start talking about a specific contextualized example (like the windstorm that occurred last week and the damage it did locally). Specific events that are local, or personal, or simply part of everyday experience are always more accessible to students as starting places for more demanding questions.

Your data collecting might reveal that you've asked a question to start the class, but without orienting students to how it relates to an activity done the previous day. Or it could be that students do not have the background experiences to understand what the question is asking. One teacher who asked students what the types of energy were required to bring a roller coaster to its starting position at the top of a track did not realize that many of his students had never been to an amusement park.

Meta-cognitive questions in the classroom

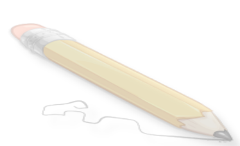
Meta-cognitive questions ask kids to think about their thinking. In the research literature on learning, asking students to reflect on their own thinking has consistently been linked with growth in conceptual understanding, reasoning, and problem-solving. These kinds of prompts aim to get kids to self-monitor their thinking to judge for themselves whether they are understanding an idea. Meta-cognitive questions also can help a student self-regulate their progress towards important project goals. For example, a teacher may ask students working together on a project to write or talk about:

- What progress am I (are we) making on this problem?
- How will I know if I am (we are) successful?
- What gaps do I (we) have in my (our) thinking?
- What additional information or experiences do I (we) need to be successful?
- How has my (our) thinking changed from a few days ago?

Using meta-cognitive questions help make students more independent of the teacher—rather than needing the teacher to tell them about the quality of their thinking, kids learn to fairly judge it for themselves. They are not used to thinking this way…so they'll need the scaffolding. It also helps them manage their time and effort across class activities that take a while to complete.

What are the first steps to using talk more productively?

Expert teachers cultivate high quality classroom discourse. But this kind of expertise is *learnable*. What does it take? Nothing more than *deliberate practice*—figuring out what aspects of discourse described in this chapter you want to work on with students, then being methodical about trying out "pieces" of talk and assessing how students respond. We can help you with places to start. Consider the checklist here. It represents a kind of discourse environment that you can aspire to. Which one of the items could you focus on for a few class periods? Consider with some of your peers how you might collect data on the moves you try and the resulting talk from your students.



- ☐ The classroom **environment will be safe** for students to express their ideas.
- ☐ **Goals of classroom discussions** will be **anticipated** by the teacher and made clear to students.
- ☐ The **teacher and students will model interactions** that foster critiques of unsupported ideas while encouraging the sharing of ideas and respect for those who are sharing.
- ☐ **Focal questions** and tasks will be predominantly **of high cognitive demand** for making sense of science ideas and phenomena.
- ☐ Strategies for **allowing time to think** in whole class discussions will be used (wait time, think-pair-share).
- ☐ A **variety of discourse moves will be used** to manage the initiation and development of ideas while at the same time honoring the thinking of all members of the class.
- ☐ Students' **puzzlements and ideas will be treated as resources** for the learning of the whole class.
- ☐ Students' language and forms of **communication will be scaffolded** from what they bring to class toward more academic ways of speaking.
- ☐ **Meta-cognitive questions** will be part of all lessons so that students learn to assess their own thinking and monitor progress toward longer term goals.

If you experiment over a whole school year, you should expect to find these markers of success:

- A greater proportion of your students will participate each day.
- Students will take longer turns at meaningful talk.
- Students will expect to be pressed and more readily offer rationale for their responses.
- Students will take up some of the questioning strategies and prompts with each other, asking for example "What is your evidence?" Or saying "That's just a 'what' explanation, you need a 'why' explanation."
- Students will be better at recognizing what counts as evidence in your classroom.
- You will get better at asking good questions and prompts, so you will have fewer of them during a class period.
- Students' written explanations (with your scaffolding) will become more elaborate, well connected, and supported by evidence.

Using this document as an interpretive framework can hopefully convince you that "teacher storytelling" or "quizzing" is not how most students learn, and that good teaching is the product of having specific goals and enacting specific patterns of verbal interaction with learners.

Some teachers have a natural aptitude for fostering meaningful conversations, but no one has the all the skills to artfully design conversations. *Every* teacher, however, who takes a principled approach to classroom discourse can eventually develop an interactional expertise with student conversations that will lead to learning. We have seen this happen with many teachers—and it is inspiring to see how students from all cultural, linguistic and socioeconomic backgrounds in their classrooms are given the chance to participate and to achieve at high levels.