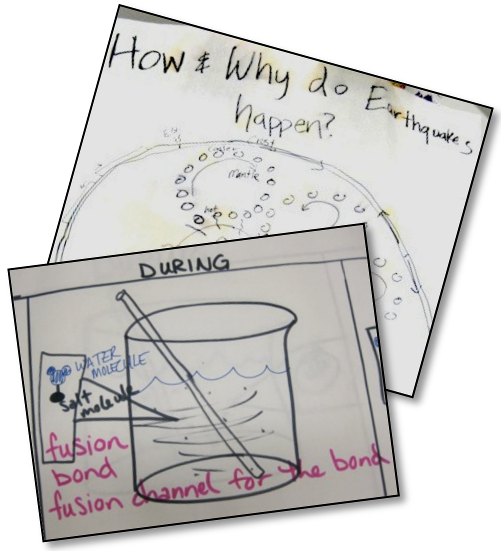
Public representations of students’ thinking



Even though *you* have a Big Idea and its ideal explanation in mind, you need to help kids reason about this explanation with ideas *they* currently have, otherwise they will merely learn to regurgitate your explanation. One way to begin working on students’ ideas is to make on-going public representations of them. There are several ways to do this, which we describe below.

Some of these representations can start on the first or second day of a unit. They are usually put on poster paper or on part of the board at the front or side of the room. These often remain up throughout the unit, and they are periodically revised as you ask students how their thinking has changed. This is typically done in whole class discussion.

Other public representations are best created after kids have had some experiences with science activities and with ideas from readings. Other kinds of representations support a final conversation about evidence and explanation. It is important to use at least one type of public record early in the unit and to use a complementary type later in the unit. These are many combinations of how these can be used in the same unit.

First or second day of unit, you could use	After rounds of activity and reading, you could use
#1 Initial consensus model #2 Small group models #3 List of potential hypotheses	#4 Explanation checklist #5 Evidence buckets #6 Summary table of activity, evidence, explanations #7 Post-it notes: comparing two explanations and their evidence #8 Post-it notes: linking evidence with a single explanation

One caution here: In any representations of thinking, you may end up recording students’ ideas that are fragmented or not scientifically valid, however you don’t want to highlight incorrect ideas in ways that make students think they have unquestioned validity—students may believe alternative understandings are scientifically valid if they see them publicly displayed in ways that make them indistinguishable from more coherent concepts. The examples below show ways to record partial understandings and students’ questions and hypotheses without confusing them.

As with all the other public records of kids’ thinking, the teacher must foster a classroom environment where everyone feels comfortable in sharing ideas and not constantly worrying about being “wrong.”

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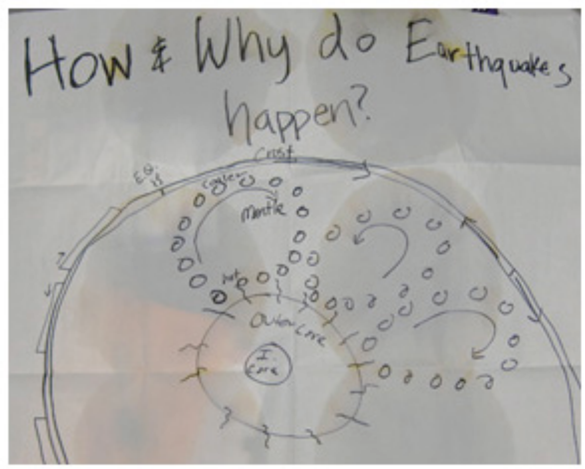
Public representations to help students organize initial explanation(s) (Create in the first day or two of a unit)

1. Initial consensus model.
This is done immediately after students have had some introductory experience with a puzzling phenomenon. On a piece of poster paper, blackboard, or whiteboard, draw a very basic pictorial representation of the phenomenon that you are exploring. Then, with input from students, put labels on this drawing that indicate any of their hypotheses about underlying events or processes that influence the phenomenon. These are the students' initial hypotheses in diagrammatic form. The teacher coordinates drawing this initial consensus model, with help and input from students. The teacher also should make explicit what conventions will be used in this and other drawings that represent the phenomenon (i.e. What do we all agree that arrows will mean? How will we agree to draw molecules? How will we show that time is passing?).



As the students engage in upcoming rounds of activity and discussions, they should (with your assistance) *decide how they want to change the model*. This could be 1) revising parts of it, 2) adding more to it in terms of specifics, it could be 3) removing some parts of it, or it could be 4) making new links between parts of the model.

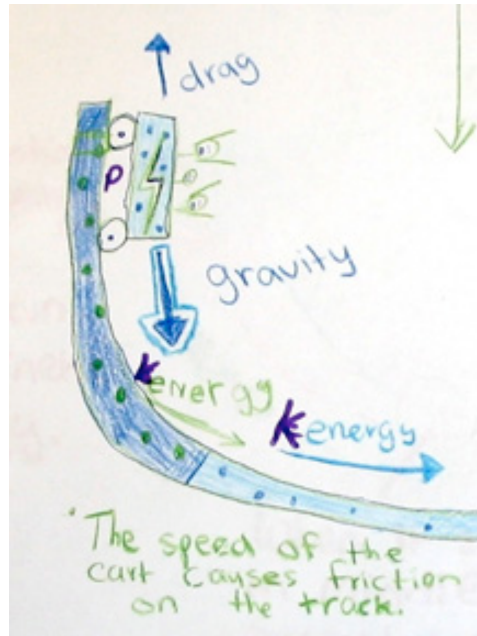
At first, these drawings should be spare (simple, not cluttered). Kids may have only idea "fragments" to contribute that are not necessarily contradictory to the scientific explanation, only very simple. These are ideal for noting on the consensus model, because they can be *built upon and changed later as students learn more*. Also, use student language in the initial model rather than imposing scientific language at this point. It's their model.

If there are clear misconceptions that kids think should be part of this model, then you'll have to think of a way to label these as "still in doubt"— you can, for example, label them with large question marks to indicate the tentative nature of these ideas.

Next to the drawing or below it there should be space for "Questions we still have about…" This will tell you a lot about what parts of the big idea they are interested in. You should capitalize on these questions in your instruction and use their questions to identify where their "gaps" currently are.

2. Small group models

As an alternative to the whole class model, kids in small groups could create their own initial models or explanations. These could be representations of the puzzling phenomenon that the teacher has introduced on the first day. Students may need some "template" to use in order to get a drawing started.



For example, one of our teachers used a rough outline of a roller-coaster to have kids draw out their initial ideas about how potential and kinetic energy explain the motion of the cars. In another classroom where the teacher was talking about density and buoyancy, she had them do a 3-part "panel drawing" of a plastic canister that was filled with alka-seltzer and then submerged in water. The kids were asked to draw a "before", "during," and "after" sketch in which they labeled not only what was visible (their observations) but also their theory about what unobservable forces and events might be causing the sinking, floating, and sinking again of the canister. We have learned that the *before-during-after* drawings are particularly helpful for kids to show that they think is happening. We have also found that for micro-level events, it helps if you ask students to "draw what you would see if you had microscope eyes." It sounds simple, but works well.

As the unit progresses, kids will learn more scientific ideas and have experience with activities that will allow them to make changes in these small group models. Kids can be asked to re-draw their models or add to a sparse model that they had started with. There are many possibilities.

3. List of potential hypotheses.

You can list potential hypotheses that kids initially have about "what's going on" in the target phenomenon. These answer the question, "What might be contributing to or causing X?" These hypotheses can be very simple to start with. They are usually a mix of one-sentence observations, inferences, and mini-theories, but they are not full blown explanations. Don't deny kids' contributions because they are brief or because they aren't using scientific language.

This might be followed by probing kids for more pieces of their causal story. Place a question mark behind each hypotheses at first so students understand that the hypotheses are not yet supported by evidence. As you then engage in cycles of reading, activity, and connecting with

Hypothesis 1. "The foam is pushing the air up into the balloon."

Hypothesis 2. "The air is warm in the flask, and it is rising."

Hypothesis 3. "Something is going on like when you mix baking soda and vinegar."

Hypothesis 4. "The yeast is coming alive and is producing a gas of some kind."

students' everyday experiences, you can gather evidence and ideas that can be applied to the list of hypotheses. Some hypotheses might get crossed out as implausible, others might be supported, others might be elaborated upon as time goes on, and some hypotheses might be linked with others. Interestingly, this is exactly what happens in authentic science.

Next to the list or below it there should be space for "Questions we still have about…"

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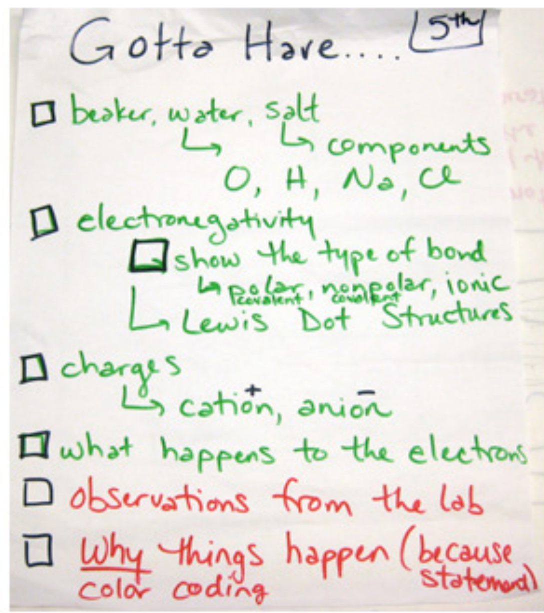
Public representations to help students coordinate evidence with their explanations (Follows rounds of activity and reading)

4. Explanation checklist.

This is more constructed by students than by you. It's a checklist of what ideas or concepts they think must be included in the final explanation. This may start with very simple statements or even just terms, but the list should grow over time—added to by students, not the teacher. Again, as the students engage in cycles of reading, activity, and connecting with their everyday experiences, students add to this list. If they are missing some key elements of the final causal explanation, it should alert you as the teacher to modify your instruction to address these missing pieces.

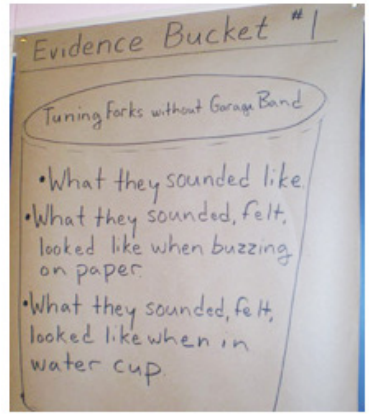


The students need to know what it is they are trying to explain, so the checklist is often combined with the early development of an initial consensus model (see #1 or #2 of public representations of student thinking).

5. Evidence buckets.

As students engage in doing various activities and reading about new science ideas, they need to 1) remember what they've learned from each activity, and 2) place what they've learned into an organizational framework so they can more easily use that knowledge and use it in the form of evidence for explanations.

In one example, a teacher working on an evolution unit conducted a series of lessons aimed at the question: Are humans similar or dissimilar to other primates? Early in this unit, she put up poster paper and drew 4 "buckets" of evidence. One bucket dealt with the amino acid structure in tissues of humans and other primates. Another bucket was for skeletal morphology, another was for brain structure, and another for behavior (mating, territoriality, troop cohesion, etc.). As students engaged in various readings and activities, they, together with the teacher, began to place evidence for or against the similarity hypothesis into the buckets. Near the end of the unit, the students were asked to *look across* the various types of evidence and make comparative judgments about the strength of the similarity hypotheses.



In creating names for the bucket categories, a teacher should consider what the source of the evidence is or consider how the evidence could be used to make judgments about the hypothesis, explanation, or model. It is helpful if more than one type of evidence can go into a bucket category. This categorization into bucket categories is a lot like what scientists do and how they talk about "types of evidence." It prompts kids to refer to evidence they have discovered by the way it can be used (such as "genetic evidence"), rather than referring to it by the arbitrary name of the lab exercise that generated it (i.e. "the opposable thumb lab").

As with the other public records in which students are talking about evidence and explanation, they need to know what it is they are trying to explain, so the use of evidence buckets is often combined with the early development of an initial consensus model (see #1 of public records of student thinking).

6. Summary table of activities, evidence, explanation

This is a table with four columns—1) Activities we did, 2) Patterns or observations, what happened?, 3) What do you think caused these patterns or observations?, 4) How do these patterns help us answer the essential question or puzzling phenomenon?

Summary Table

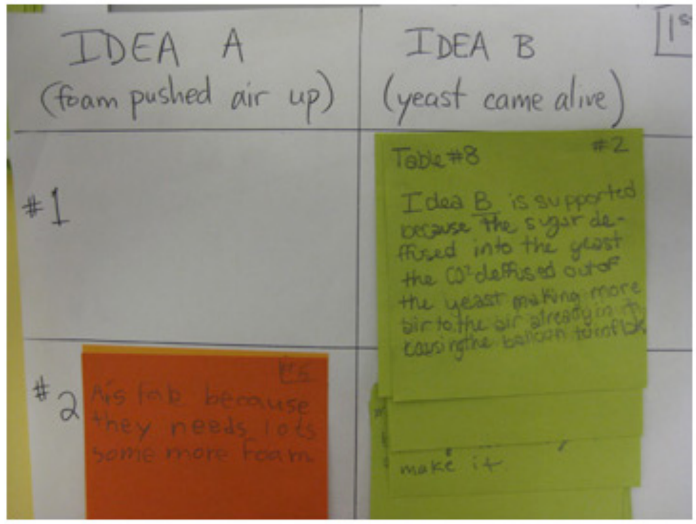
[*Essential Question* or *Puzzling Phenomenon* goes here]

Activities we did: describe each briefly and or draw a picture.	Patterns or observations—what happened?	What do you think caused these patterns/observations? Use what you've read to explain.	How do these patterns help us answer the essential question or figure out the puzzling phenomenon?
1.			
2.			
3.			
4.			

The table is placed on a wall in the classroom and it remains up throughout the unit. After each round of reading and activity, students are in charge of discussing how the activity helps them think about the big idea, and filling in one complete row. As the unit progresses, more and more rows get filled in and, ideally, students start to piece together a more coherent and complete explanation by looking "down" the fourth column.

7. Post-it notes: Comparing evidence and competing explanation(s)

After a couple of activities and readings, you may be ready to ask students to start a public conversation about how the evidence they've generated can support or contradict an explanation. One way to do this is to place on the board (or a piece of poster paper) two competing explanations for the phenomenon or puzzling question that you've based your unit on. Ideally, one of these can be an explanation that some of your students had originally favored, but is not complete or lacks scientific cohesion. The other explanation should be scientifically coherent, and ideally also generated by your students. Under each explanation is a list of the activities or readings the students have done recently.



Then, in small groups, students are given a prompt (such as a picture) from a lab activity or reading they have done. On this prompt can be some statement about what the key ideas were that students have learned from the activity or reading—this could have been generated by the students themselves when they did the activity. All the small groups can then spend 5 or 10 minutes deciding if what they had learned from that activity or reading supports one or both of the explanations, or if it contradicts one or both of the explanations. If it supports an explanation, they can write on a yellow post-it note why it supports a particular explanation. If it contradicts or does not support an explanation they can use a blue post-it and explain why. At the end of this round a student from each group comes up to the board and in the box that represents that particular activity or reading (below one of the explanations) they can place their post-it note.

The teacher then reviews the post-it notes with students and moves on to the next type of evidence. There may be 1 or 2 rounds of this activity during a class period. The teacher can decide to have a whole class discussion after each round or wait until the final round to engage in this discussion.

This can be repeated two or three times during a unit, and the post-it table can remain up in the room in the interim.

Caution! This activity does not, by itself, help kids come up with a rich causal explanation; you should couple this activity with going back to some whole group model or small group models, and have kids periodically re-write or re-draw their causal explanations.

8. Post-it notes: Comparing evidence about a single explanation

Because the whole idea of talking about evidence can be unfamiliar to students and the idea of comparing two explanations is also challenging at first, you can do the post-it note activity, but use only a single coherent scientific explanation that kids have helped construct. Although it may not represent the full causal story yet, it is helpful to use the students' explanation to support this activity. The students will participate in the same small group deliberations, but they will focus on whether the evidence they have supports, does not support, or contradicts the one explanation. After the rounds are complete, the teacher can have a summary discussion in which gaps in the students' explanation are questioned, in addition to seeing what evidence has supported the explanation.

This can be repeated two or three times during a unit, and the post-it table can remain up in the room in the interim.

Caution! This activity does not, by itself, help kids come up with a rich causal explanation; you should couple this activity with going back to some whole group model or small group models and have kids periodically re-write or re-draw their causal explanations.