Teach ME Outside

BEST PRACTICES

Maine Mathematics and Science Alliance

**A Guide and Toolkit for Educators to Incorporate
Best Practices in Science Teaching
Into Their Environmental Learning Programs and Lessons**

How to Use This Toolkit

This toolkit is designed to be a simple and time friendly guide to take the work you are already doing in your environmental learning programs and lessons and shift them from **students "learning about" content to "figuring out" content.** It places the learning and the students at the center, and **it is something the students do, not something done to them**. These are not radical shifts in your programming, but a way to support what is already being done well in so many formal, informal and non-formal, large and small, rural and urban learning environments.

Use this guide to:

- Learn about core research-based shifts in science education that have been proven to improve student outcomes
- Explore concrete examples of how minor changes in lessons can be incorporated to move students from "learning about" to "figuring out"
- Workshop your own lessons using a series of "Best Practice" tools
- Engage your colleagues in a discussion about how to adapt and improve your lessons

Acknowledgements

This module was developed as a part of the Teach Me Outside project. Teach ME Outside builds on the collaborative work of many different organizations and individuals over the past decade and is led today by a partnership between the Maine Mathematics and Science Alliance (MMSA), the Maine Environmental Education Association, and the Nature-Based Education Consortium. This project is made possible with support from the Pisces Foundation, the Elmina B. Sewall Foundation, and the Onion Foundation.

Teach ME Outside

MMSA Maine Mathematics and Science Alliance

Maine Environmental Education Association MEEA

NATURE BASED EDUCATION CONSORTIUM

Table of Contents

1. Introduction - Why Should I Incorporate Best Practices Into My Work?

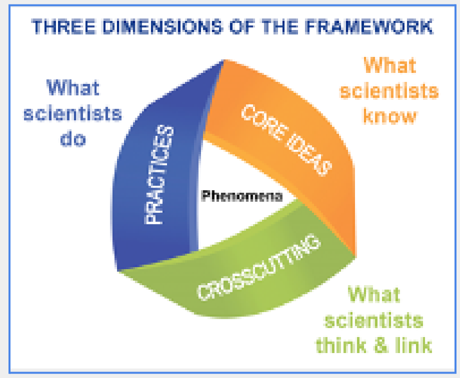
The single most coveted yet dwindling resource educators have – or don't have – is time. The impetus for this *Best Practices Module* is to help support what is already being done in so many formal, informal and non-formal, large and small, rural and urban learning environments. **Teaching Best Practices in Science Learning is nothing more than doing what we already know to be best, in our interest, and the students' interests**. It puts more teacher effort on the front end, allows for flexibility throughout, and prepares (with reasonable expectations) students in the end. Continue to do what you already do but elevate lessons using some of these new tools and strategies. Swap out, in, or alongside what is already happening in your learning space and understand pedagogically why you are making these changes.

These tools can be introduced gradually until you feel confident in their effectiveness. Not all lessons need to include all the best practices – some will. There is not a wrong way to do this, but there is no better way to improve learning. This sort of sensemaking means **shifting away from students "learning about" content to "figuring out" content.** It places the learning and the students at the center, and **it is something the students do, not something done to them**.

It seems that sometimes in education, the more we learn, the less we know, and for this reason alone, this module of best practice tools, lesson examples, and adaptation guidelines have been kept simple and time friendly.

This guide is organized to provide some background information and rationale for adapting curriculum, best practice tools and examples that you can use in your own work, and space for adaptation work and reflection on your own lessons. We hope you find and use this guide as a practical working space!

2. Defining Curriculum



When we think about curriculum, any curriculum, we should think about it in the context of 3- dimensional learning. That 3-dimensional context includes: Content Standard, Practice, and Cross-Cutting Concept. Teaching all three reflects best practice and this module guides its inclusion into what you are already doing. **It does not require you to significantly change what you do, but it does elevate how and why you do it.**

So together, the 3-Dimensions are WHAT students are able to DO with their new understanding of the content, HOW they make sense of the content, and WHY they are learning it in the first place.

The Disciplinary Core Ideas (DCI)
This is your local, state, or national content standard, and it represents only the partial content you must teach. **This is WHAT students are learning.**

The Cross-Cutting Concepts (CCC)
This is the list of big principles that are taught in and across every grade level K-12 and links the different domains of science. **This is WHY connections to larger scientific principles are so important to sensemaking.**

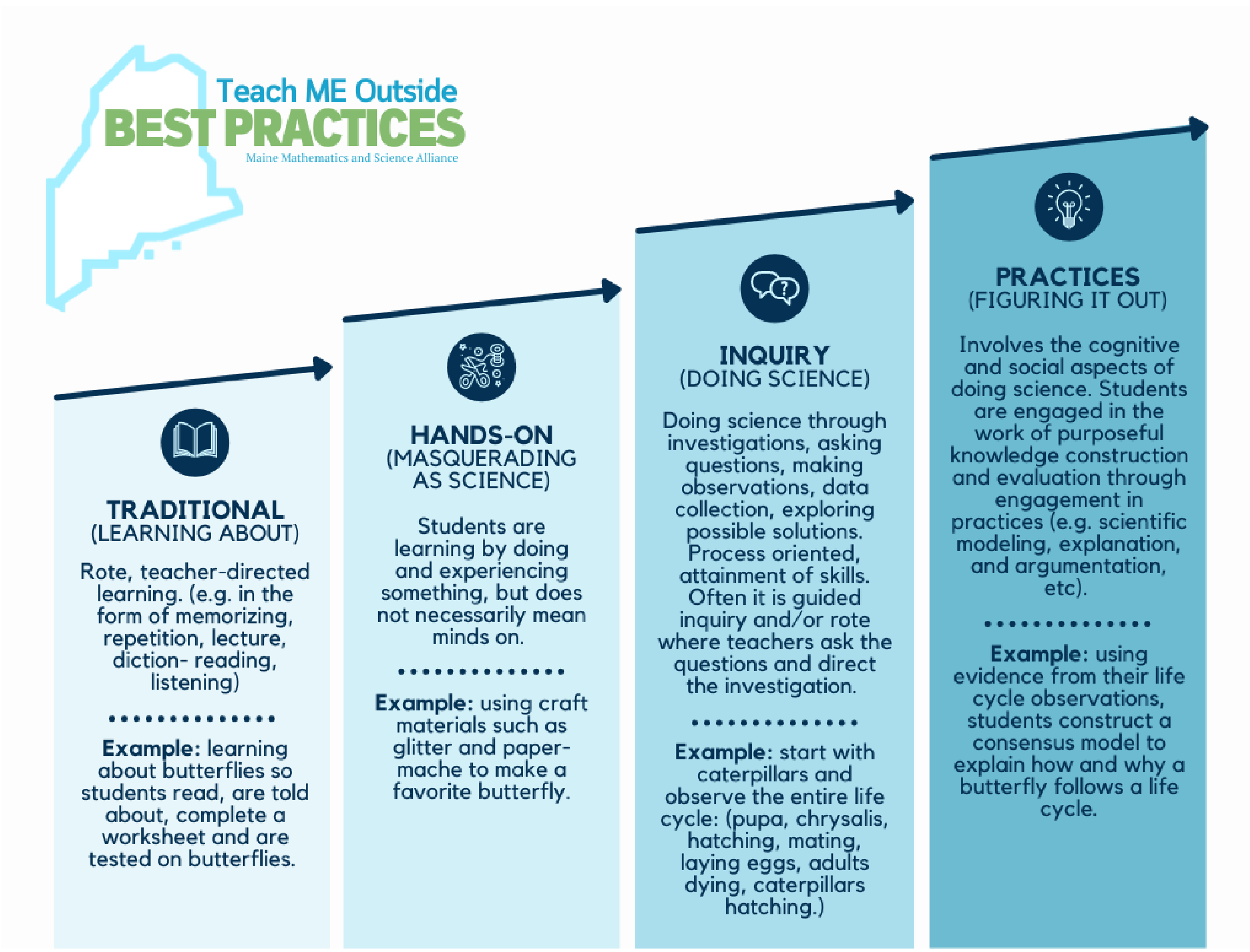
Patterns	Cause & Effect	Scale, Proportion & Quantity	Systems & System Models	Energy & Matter	Structure & Function	Stability & Change

The Scientific Practices
This is what students are able to actually DO with the content they learn. This is the WHY and HOW students come to understand the content standard. There is a continuum of the way this happens from less effective to more effective. **This is HOW students demonstrate what they are learning.**

Additional Resources: *Cultivating a next-generation classroom culture*. *Science Scope. NSTA The Science Teacher.* January 2016. By Christina Krist, Lisa Brody, Michael Novak, and Keetra Tipton

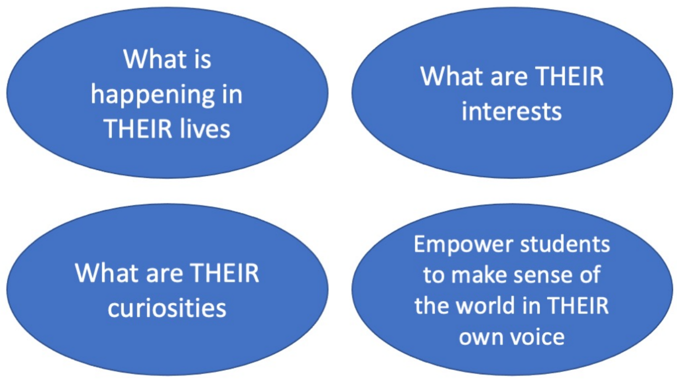
3. Teaching Continuum

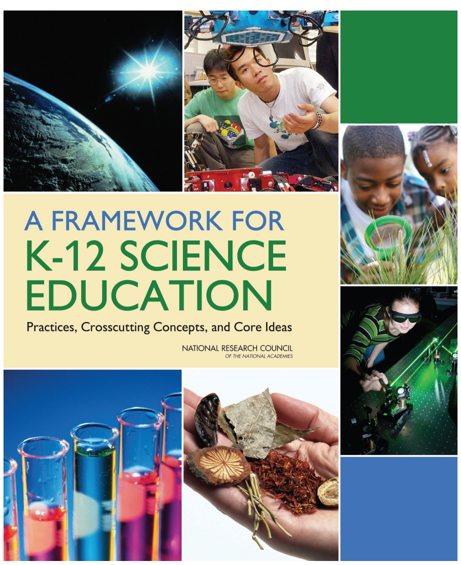
The below graphic outlines what "learning about" and "figuring out" looks like from both a teacher's and learner's perspective. All four categories can have a place in teaching, but Best Practice captures all the other categories, and puts coherence from students' perspective foremost and makes the knowledge useful. The tools in this toolkit will help guide your teaching.



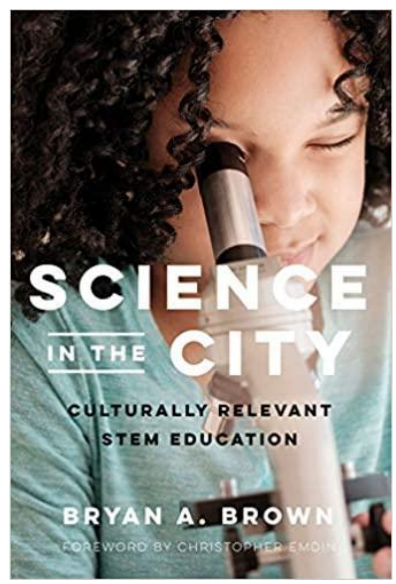
4. Adapting Curriculum

Recent research and reform argue that curriculum should be coherent for students. Student coherence supports equitable sensemaking, but only if we educators teach from the students' perspectives rather than ours.





"Designed to help children continually build on and revise their knowledge and abilities, **starting from their curiosity about what they see around them** and their initial conceptions about how the world works." (NRC, 2012)



"Impactful science teaching happens when we start in the lives of the children and empower them to make sense of the world **in their own voice.**" (Brown, 2019)

In traditional approaches to teaching, units are sequenced based on how experts understand the relationship among concepts. This means that it typically requires a prior understanding of the concepts being taught to understand why a unit is sequenced the way it is.

Students don’t have that, but you do. The result is that the sequence of activities may make sense to the teacher but does not necessarily make sense to the students.

For example, you may understand how certain activities to learn about cells will help students understand important biological concepts, but students may only know that they are learning about cells because that’s the title of the current chapter in the textbook or because you told them.

In the **Science Best Practices** approach, the sequence of activities is designed to make sense to students. We call this **“coherence from the students’ perspective.”**

When a unit or series of lessons are coherent from the student perspective, a visitor to the classroom on any given day, should be able to walk over to a student or group of students and ask, “what are you learning” or “what are you figuring out?” [We hope visitors are not asking students, “what are you doing?” Asking, “what are you doing,” is a closed-ended question, because it can be answered in a few words. Student: “we’re learning about rocks.”]

Asking instead, “What are you figuring out?” …students have to think about that…what connections they are making, the problems they are trying to solve that deal with rocks, but it isn’t just about rocks.
In this scenario, students will be able to answer in a way that describes a question they are trying to figure out or a problem they are trying to solve.

As you are well aware, students often experience their classes as a series of disconnected activities and lessons. Science is no exception. In units that are coherent from the student perspective, educators work with students to figure out together what the class needs to work on, and how to go about it.

The sequencing of our own instruction makes complete sense to us, but we are the educators, we are the experts, we actually know the thing that we are teaching. To students, this could actually appear as a series of unrelated events.

These lessons can still be engaging and interesting (especially if they are hands-on), but to a student, it appears as “today we’re going to do Oobleck and tomorrow we’re sinking metal blocks in water, but I don’t know what they have in common.”

That is what we mean when we say, “hands on" doesn't necessarily mean “minds on.”

5. Ideas I Have Before I Start

After reviewing the introductory framing above, use this space to reflect on your current ideas:

- *What were new "a-ha" moments?*
- *What would you like to learn more about?*
- *How are you thinking of using the above information to adjust your lessons?*
- *What was confusing?*
- *What challenged your thinking?*
- *Etc.*

6. Using the Best Practice Tools - Design Framework Example

Below is an example of how each of the tools in this toolkit are arranged. Each tool is presented with a framework consisting of an example **Origin Lesson**, its **Learning Goal** and a **Best Practice Tool** used to create a **Modified Lesson**. Completing the framework are **Prompting Notes** and **Guiding Discussion Questions**. The Best Practice Tools are presented as an appendix at the end of this document in full-page format for easy readability.

Learning Goal  The tool, question for why and how to use it, and the point of the lesson.	**Origin Lesson** Learning About (What) A traditional or hands-on lesson that is pre-designed or designed by you that focuses on teaching the standard for standard's sake.
Best Practice Tool(s) These infographic diagrams provide you with an easy visual of the teacher moves you are making through a lesson(s).	**Best Practices Modified Lesson** Figuring Out (Why and How) An inquiry/practices lesson that allows students to understand and apply that standard so they are **interested** in learning it, know **why** they are learning it, and can **apply** the knowledge to their world.

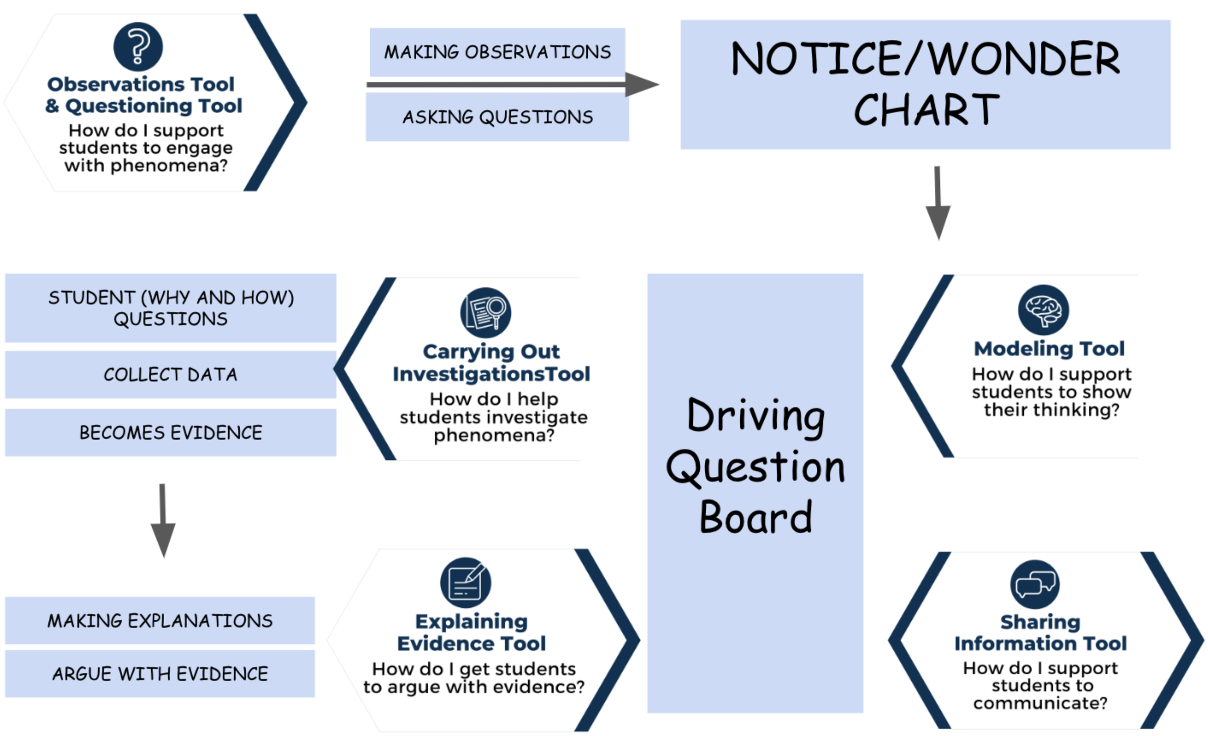
Prompting Notes

Ideas, tips, and context to help support your approach to modifying a lesson(s).

Guiding Discussion Lessons/Questions

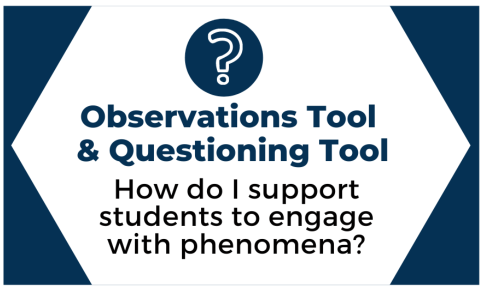
Prompts to get you thinking and applying your pedagogical content knowledge.

BP Tools Navigation Route



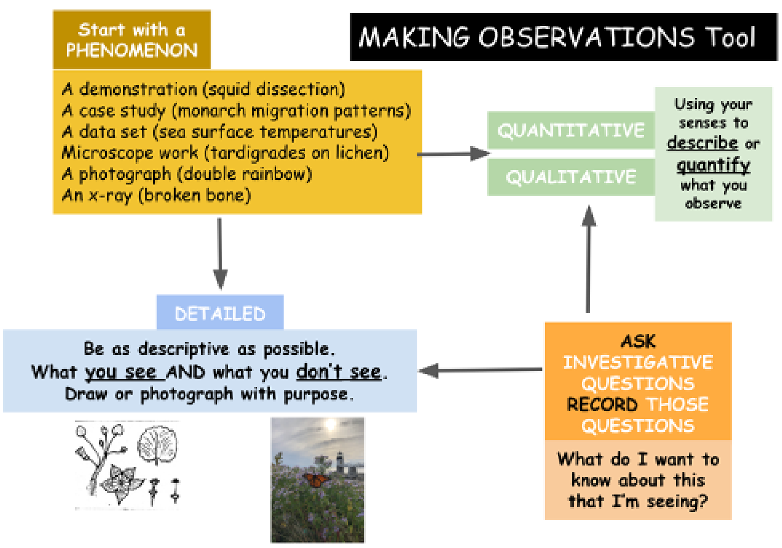
Best Practices Tool 1: Observations and Questioning

Learning Goal
Owl Pellets – Predator/Prey Relationships and Dissection



Origin Lesson
Learning About (What)

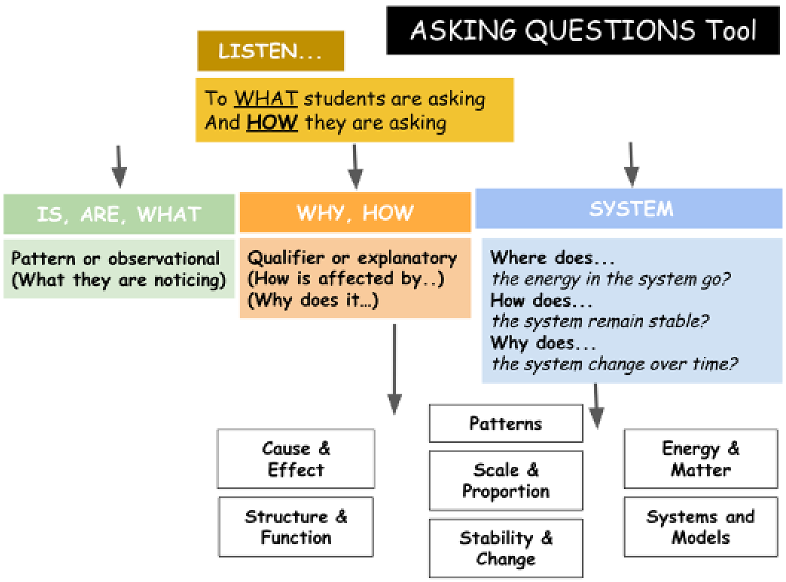
Educators pass out the owl pellets and students are working with partners. A worksheet describing what an owl pellet is and identifying what is inside the pellet is provided. Students begin to remove the hair from the pellet and pull out what they find. They try to match what is inside the pellet to what is on the worksheet and are asked to try and assemble the bones into a semi-complete rodent/bird skeleton. The class talks about what owls eat.



Best Practices Modified Lesson
Figuring Out (Why and How)

Before starting their dissection, have students spend 5 minutes observing the **Phenomenon**: their owl pellet. During this time, students should make a two-column table with the headers, "I Notice and I Wonder" to help stimulate observations and questions. Once the students have had time to come up with noticings and wonderings about their owl pellet, discuss as a class ways to group those observations into quantitative (numerical) and qualitative (descriptive) categories.

This portion of the lesson connects to the Practice of **Making Observations** and **Asking Questions** because students generate their own questions about owl pellets through firsthand observations using the "I Notice" and "I Wonder" prompts. Questions that are generated from student's firsthand observations help them to develop their own ideas and explanations for phenomena in the natural world. Students' questions can be recorded on a worksheet or



whole class chart paper. Students use those questions to guide their dissection of the pellets.

Listen for the types of questions students are coming up with. Besides the expected, "What is it?", most questions will probably be "why" and "how" questions. Depending on the phenomenon, those "why" and "how" questions may cross into "system why" and "system how" questions* which are higher order thought and can be encouraged the more practice students have with this approach.

Students' questions can now be grouped** into the seven Cross Cutting Concept (CCC) categories in the tool to the left.

These concepts are taught in every grade level with increasing sophistication. Knowing "what" your students are thinking is important but knowing "where" they are thinking provides you with a learning gain measurement context and a growth mindset continuum.

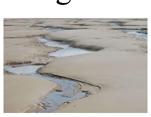
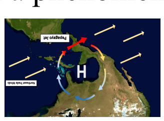
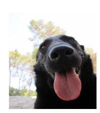
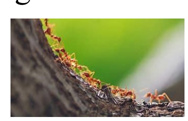
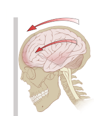
* IS, ARE, WHAT: Pattern or Observational Questions
What are students noticing?

*WHY, HOW: Qualifier or Explanatory Questions
How is it affected by…?
Why does it…?

*SYSTEM: Parts of a Larger Whole Questions
Where does…the energy in the system go?
How does…the system remain stable?
Why does…the system change over time?

** Grouping questions can be done during class or after class by the educator in preparation for the next day

Prompting Notes
If the content you are teaching is not interesting to you, it will not be interesting to the students. You must put the information into a context that is interesting, so students understand why they are learning it, and will want to learn it. Begin with a phenomenon where students can notice things happening and wonder about them.

Guiding Discussion Lessons/Questions

1. An easy and consistent 2-step move you can do in any lesson is to start with an observation of a phenomenon and then ask students what they **Notice and Wonder** about that phenomenon. Talk with your colleagues about lesson examples you currently teach that could be adapted to include these 2 steps.

Use this space to workshop an existing lesson to incorporate "Noticings" and "Wonderings."

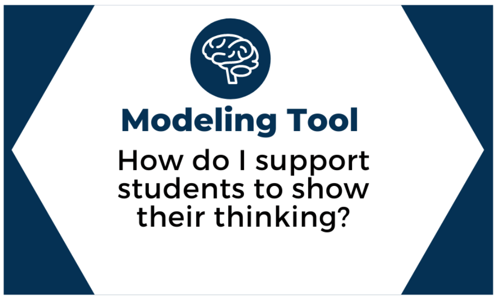
Additional Resources:

The Driving Question Board. A Visual Organizer for Project Based Science. November 2008. By Ayelet Weizman, Yael Schwartz, David Fortus.

Scientific and Engineering Practices in K-12 Classrooms. Understanding A Framework or K-12 Science Education. NSTA *Science Scope.* December 2011. By Roger Bybee.

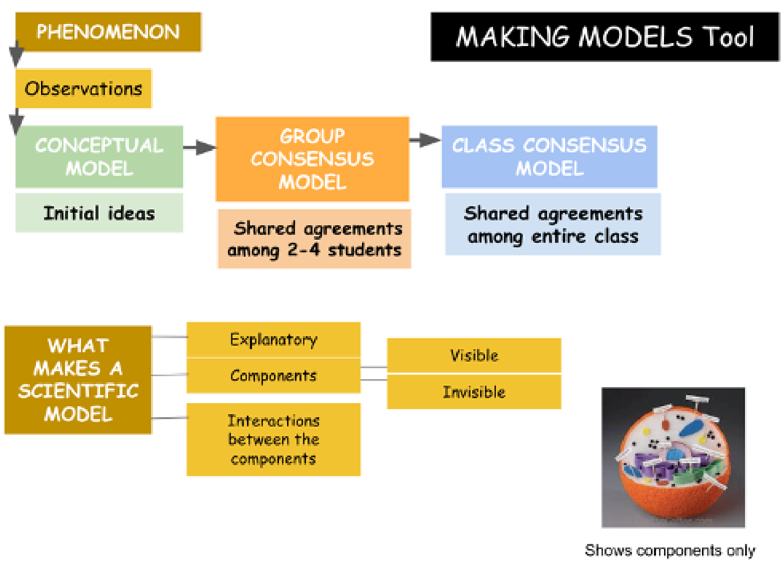
Best Practices Tool 2: Modeling

Learning Goal
Evaporation – Systems and Cycles



Origin Lesson
Learning About (What)

Understand the water cycle by having students act it out. Each student gets a note card with a water cycle word (evaporation, precipitation, transpiration, condensation, percolates, run-off). Students act out the word and without talking, they are to group themselves with other students they think have the same card. One at a time each group shows the rest of the class their action. Then choose a leader from each group and have that student dramatize the entire water cycle. Have the groups draw the water cycle on large butcher paper. Discuss the water cycle with the students.



Best Practices Modified Lesson
Figuring Out (Why and How)

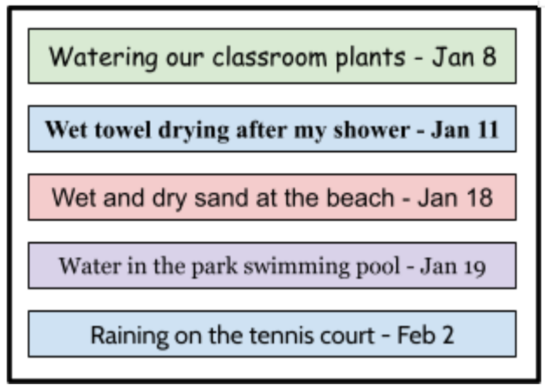
Have students spend 15 minutes observing the **Phenomenon**, a puddle outside. During this time, students should make a two-column table with the headers, "I Notice" and "I Wonder" to help stimulate observations and questions.

Ask students to draw and use words on a piece of paper demonstrating how they think the water got there[1], stays there[2] and will leave[3]. Encourage them to not just put down what they see, but also what is happening that they cannot see. [A similar model example of condensation is below].

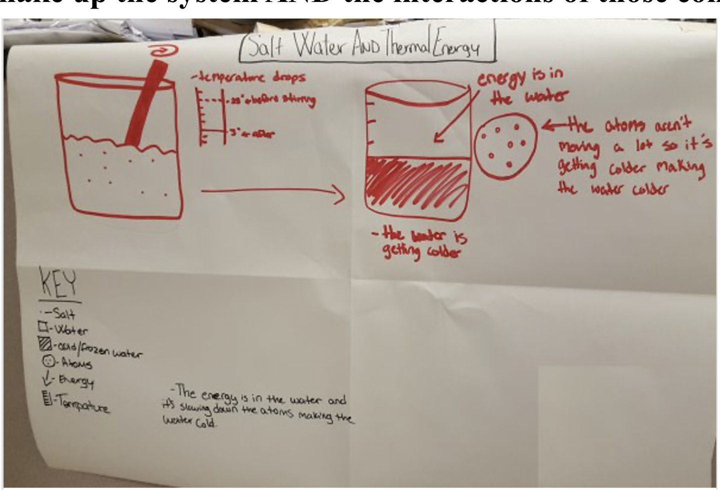
Put students in partners and have them talk about what they drew and why. Ask students to think of other examples, both bigger and smaller, that they can think of that might be similar. Have students write their examples on sticky notes and keep a "phenomena tracker"* of them on the wall in the classroom. Use those examples to begin to investigate and collect evidence that helps students understand the mechanisms of cycles. Gradually revise their initial **models** over the course of the investigations until you can all reach a consensus model (entire class model) of the water cycle (really it is water cycles, with an "s" to be scientifically accurate.)

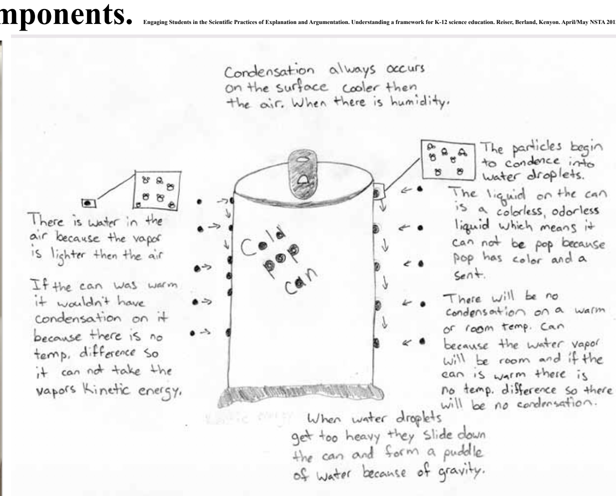
Note: you can still have students do the above origin lesson, but don't start with it because it is out of context for them.

* A "Wall Phenomenon Tracker" is a way to keep track of like-phenomena that are similar to the initial one (in this case, the puddle) that your students could think of to explore and gather evidence about the concept of evaporation. [Examples of what might be included in a wall tracker of similar phenomena for this particular learning goal.]



Prompting Notes
For students to really understand new content, they must know why they are learning it and how it connects to other content. That is what distinguishes memorization from learning. The scientific practice of modeling and revisionist modeling provides that rationale. **Models (examples below) include BOTH the components that make up the system AND the interactions of those components.** Engaging Students in the Scientific Practices of Explanation and Argumentation. Understanding a framework for K-12 science education. Reiser, Berland, Kenyon. April/May NSTA 2012.





Guiding Discussion Lessons/Questions

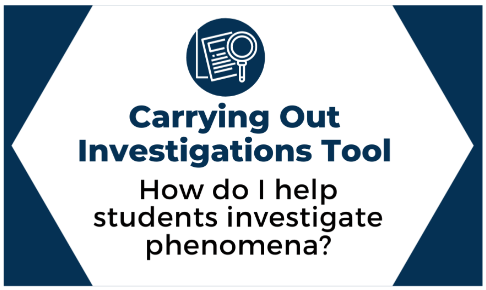
Knowing what your students are thinking is probably the most important thing you can do as an educator. Starting with each student's initial, conceptual model build and transitioning to small and large group conceptual model builds gives you that preliminary information. Think of some of your top content standards that you teach and talk about how you would know your students really understand them besides them doing well on a test.

Additional Resources:

Engaging Students in Scientific Practices: What does constructing and revising models look like in the science classroom? Understanding A Framework for K-12 Science Education. NSTA K-12 Journals. March 2012. By Joseph Kracik and Joi Merritt.

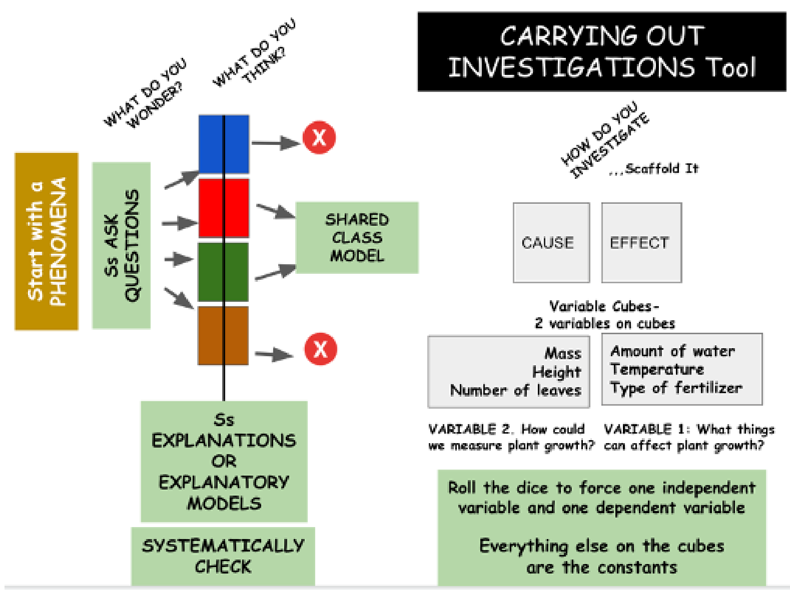
Best Practices Tool 3: Carrying Out Investigations

Learning Goal
Abiotic factors' influences on biotic organisms



Origin Lesson
Learning About (What)

Determining a local stream's health. Students measure the water temperature, depth and clarity. They may take some water samples and use kits to determine salinity, conductivity or dissolved oxygen. This can be a lot of measuring, but without much context to what it all means for the health of the stream and organisms in the stream, it is a hands-on activity. Certainly fun to be outside and in the water, but learning how to interpret data into evidence is a performance task that must be taught and practiced often.

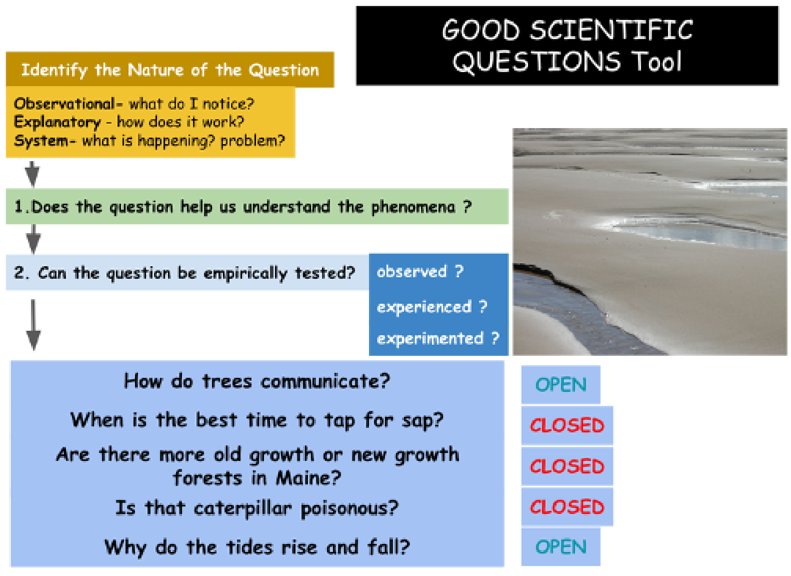


Best Practices Modified Lesson
Figuring Out (Why and How)

Have students spend 15 minutes observing the **Phenomenon** (the stream) and look for surrounding plant life and listen for wildlife (birds/insects.) During this time, students should make a two-column table with the headers, "I Notice" and "I Wonder" to help stimulate observations and questions.

Investigations can take many forms. They do not always have to include manipulating variables. It can be as simple as making observations and taking some sort of measurement (circumference of a tree, count the number of crayfish in a particular area of stream). What defines an investigation is that students are recording and interpreting data.

Carrying out investigations actually starts with student questions, like always, but now those questions need to be elevated a bit. The nature of the question will determine how successfully you can go about an investigation. Begin with



listening and guiding students' closed questions toward more open questions. For example, a student may ask "Is that fish poisonous?" You can guide this towards a more open-ended question like, "How do fish protect themselves from predators?" This will make data collection and interpretation a richer experience.

Streams can be monitored by seining, collecting, and counting small aquatic organisms (macroinvertebrates) such as insect larvae, crayfish and snails. Macroinvertebrates are highly effective barometers of a stream's health because they have varying tolerances to pollution. The presence, quantity and diversity of macroinvertebrates can be used as an overall indicator of stream health. This scoring technique is called the cumulative index value [total number of species divided by the total number of individuals across all taxa], and it helps determine if the quality of the stream is excellent, good, fair or poor.

Maine Audubon has a "Stream Explorers Guide" here if you'd like to try this out with your students.

Prompting Notes

Every time you teach, think how you can include data collection - i.e., have students interpret data you provide, have students collect their own data (preferred), have students interpret their data, etc. The more they see data as a story with patterns, the better they will get at designing investigations to capture snapshots of understanding their natural world – just like real science and scientists.

Guiding Discussion Lessons/Questions

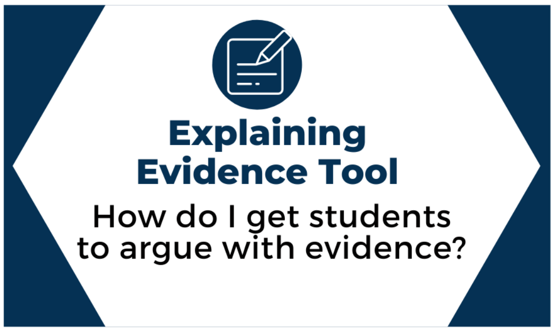
1. Think about 2 lessons that you could swap in some sort of data collection/use of data that would elevate it into a best practice investigation lesson.

Additional Resources:

The integral role of laboratory investigations in science instruction. NSTA Position Statement. https://static.nsta.org/pdfs/PositionStatement_LabScience.pdf.

Best Practices Tool 4: Explaining Evidence

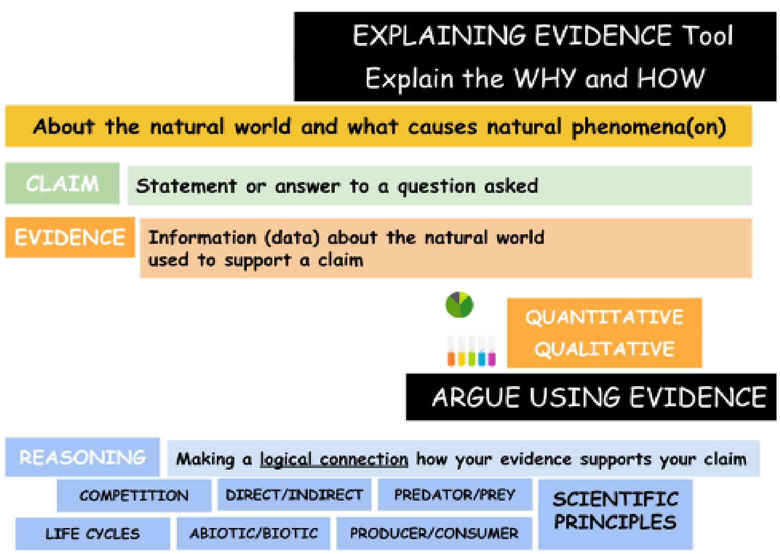
Learning Goal
Germination – Growth (primary and secondary) and Photosynthesis



Origin Lesson
Learning About (What)

How do plants respond to their environment? Have students plant sunflower seeds in pots of soil, water them, and put them in the window OR plant them outside in a school garden.

Students already seem to know that seeds need soil, water and sunlight to grow, but **this conception is actually incorrect** and planting and growing seeds this way only manufactures this misconception further because they think that what they are seeing is happening. A learning extension can be in the form of reading a book about seeds and plants but be careful that the information that the book uses is correct. **Note: Seeds don't need soil and sunlight to germinate, and plants don't get food from soil, sunlight or water.**



Best Practices Modified Lesson
Figuring Out (Why and How)

Have students spend 15 minutes observing the **Phenomenon** (different size plants growing near one another outside). During this time, students should make a two-column table with the headers, "I Notice" and "I Wonder" to help stimulate observations and questions.

Ask students where the plant seeds get the food (energy) they need and where does the plant get the food (energy) it needs. Ask students to draw an initial model of how and why some plants are taller or fatter, shorter and thinner. Students will make different **claims** based on prior knowledge from things they have heard, conceptions and guesses/ideas that they are not sure about. Explain that a "claim" is what we think about something, but because we seem to

	have different ideas about this, we need to collect some **evidence** to help us understand it better. Collecting evidence can, and will take many shapes, as you and your students think of investigations you can do to collect data. This typically starts well with putting seeds in baggies with wet paper towels and with dry paper towels. Put some in windows and some in the dark. You are building variable comparisons of evidence. You can dissect a soaked lima bean and find the embryo and cotyledon (starch), etc. Finally, begin to have students try and use reasoning (which tells others why your evidence makes more sense than someone else's evidence.) This is more challenging for elementary students, so sticking with only claim and evidence is perfectly acceptable at elementary grade levels.

Prompting Notes
When students share their thoughts with one another, it often begins with them sharing their **opinions** about the subject. Teach students early that their use of evidence makes the difference between opposing claims getting accepted or rejected. Every academic subject in addition to Mathematics and Science teaches about using evidence to support what is being said (claims), and so it is important to make that point explicit with students. Social studies teachers teach students how to use **sourcing** (*evidence*) to verify historical record, and Language Arts teachers teach students how **voice** (*evidence*) supports what is being said, by whom and when.

Guiding Discussion Lessons/Questions

1. Consider designing an interdisciplinary lesson where the mathematics, language arts, social studies and science teachers all explicitly talk about evidence in what they are teaching.

Additional Resources:

Engaging Students in the Scientific Practices of Explanation and Argumentation. *Understanding a Framework for K-12 Science Education.* NSTA K-12 Journals April/May 2012 . By Brian Riser, Leema Berland, Lisa Kenyon

Helping students write scientific explanations. NSTA Science Scope. September 2019. By Ann Novak, Katherine McNeill, and Joseph Krajcik.

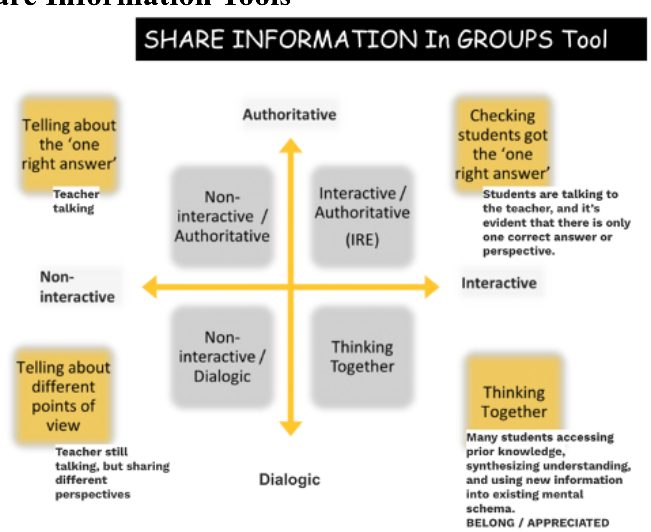
Best Practices Tool 5: Sharing Information

Learning Goal
Identify forms of pollution, effects and relationships between pollutants and human actions.

Origin Lesson
Learning About (What)

Neighborhood Patrol
Ask students to imagine what life would be without clean air. Ask students to list as many things as they can that might make the air and water unsafe. Take students on a walk outdoors to look for examples of pollution. Ask students, what kinds of plants or animals could be affected? Ask, what might have caused each form of pollution? How did the litter get on the ground? How did oil get on the pavement? Have students record their answers. Back inside, students draw pictures of the pollution. Look through magazines for more examples of pollution. Have students take turns putting their examples into categories on a large poster board. Ask these questions to the students: do any of the same items appear in both categories? If so, do you agree with where those items are placed? Can people always see, hear, or smell pollution? Ask students how each could be prevented? Finally, have the discussion that we can't prevent all pollution.

Share Information Tools

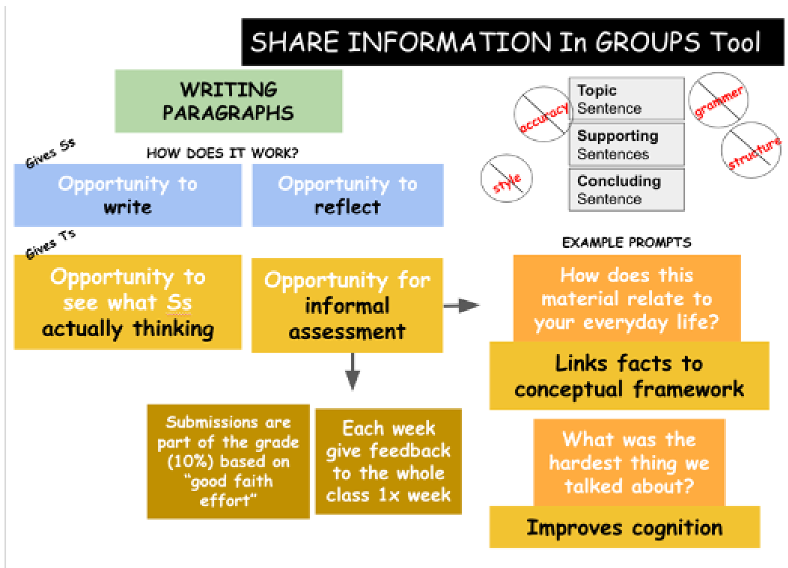


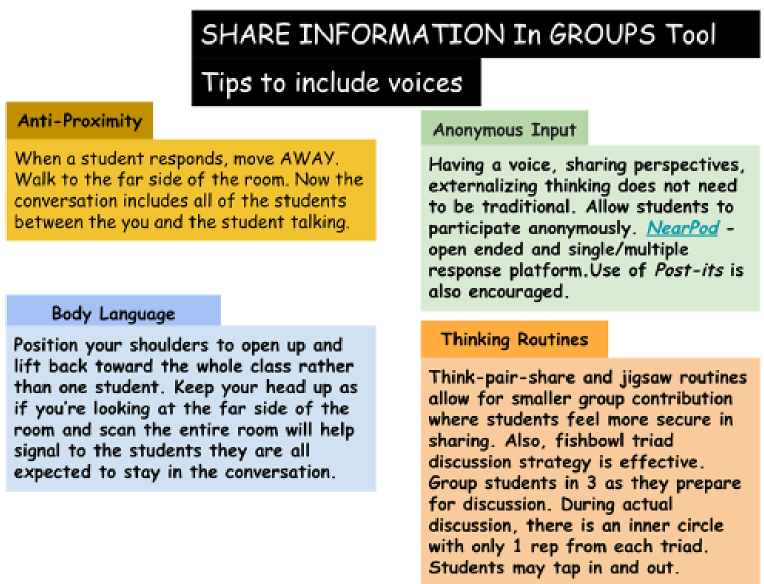
Dialogic-authoritative dimensions of discourse on an interactive–non-interactive continuum (adapted from Mortimer & Scott, 2003, p. 35).

Best Practices Modified Lesson
Figuring Out (Why and How)

The social aspects of science are rarely explicitly taught, and yet, sharing information is at the core of what science is all about. Using convincing evidence and arguing from evidence is what moves our understanding of the natural world forward. Students need to be taught how to communicate what they know, otherwise, new information cannot be assimilated.

Use any or all the **Share Information** routines in your lessons. The routines focus on 4





Adapted from TERC (2012), Talk Science in the Inquiry Project.

approaches of obtaining, evaluating, and communicating information. Some routines you* do to set the culture of shared ideas, others the students** use to help give them voice:

*your teaching style
*include everyone's voice
*productive educator talk moves
**communicate through writing

The lesson above is a barrage of IRE (Initiate, Response, Evaluate) exchanges between the educator and the students. It is a ping-pong game of talking. Instead, include the Productive Talk Moves Tool to turn this lesson into a volleyball game, where the students are engaged with one another rather than the educator.

Let the students ask the questions of each other by adopting a Dialogic/Interactive class culture. Include fewer, closed-ended questions. Ask Why and How rather than What questions. Maybe just 2 questions that cannot be answered quickly but require students to naturally think about more questions as they figure out their claims. For example, "how does pollution affect how animals survive in their space?" This open question will lead to all sorts of rich, inquiry-based investigations, modeling, evidence collecting, and explaining.

Productive Talk Goals and Moves Tool

Goal One: Help individual students share, expand and clarify their own thinking

1. Time to think: Partner talk, writing as think time; wait time.
2. Say more: "Can you say more?"; "What do you mean by that?"; "Give an example."
3. So, are you saying…?: "So, let me see if I've got what you're saying. Are you saying … " (always leaving space for the original student to agree or disagree and say more).

Goal Two: Help students listen carefully to one another

4. Who can rephrase or repeat?: "Who can repeat what Jason just said or put it into their own words?" (After a partner talk) "What did your partner say?"

Goal Three: Help students deepen their reasoning

5. Asking for evidence or reasoning: "Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?"
6. Challenge or Counterexample: "Does it always work that way?" "How does that idea square with Sonia's example?" "What if it had been a copper tube instead?"

Goal Four: Help students think with others

7. Agree/Disagree and Why?: "Do you agree/disagree? (And why?) "What do people think about what Ian said?" "Does anyone want to respond to that idea?"
8. Add on: "Who can add onto the idea that Jamal is building?" "Can anyone take that suggestion and push it a little further?"
9. Explaining what someone else means: "Who can explain what Aisha means when she says that?" "Why do you think she said that?"

Adapted from TERC (2012), Talk Science in the Inquiry Project.

Prompting Notes

Implementing even one of the above best practices tools will build the culture of student discourse, and not just between them and you, but more importantly among the students. When you hear the word inquiry, and even more precisely the word scientific practices, it is **social** AND **cognitive** aspects of science that you are having your students engage in. **Sharing observations** and wonderings with one another, **questioning one another** and **corroborating information** are the pillars of scientific discovery and literacy.

Guiding Discussion Lessons/Questions

1. Share a lesson you teach that most closely reflects the *Dialogic/Interactive* space in the Share Information in Groups Tool (or from the Teaching Continuum).
2. Select a lesson you teach that is more reflective of the *Authoritative/Non-Interactive* space in the Share Information in Groups Tool (or *Traditional* from the Teaching Continuum), and redesign/discuss how you would make it more *Dialogic/Interactive.*

Additional Resources:

Exploring the Science Framework. Engaging Learners in the scientific practices of obtaining, evaluating and communicating information. NSTA Science Scope. November 2012 . By Philip Bell, Leah Bricker, Carrie Tzou, Tiffany Lee, and Katie Van Hone.

Talk Science Primer. TERC. 2012. By Sarah Michaels and Cathy O'Connor.
http://searkscience.pbworks.com/w/file/fetch/67803311/18-TalkScience_PrimerArticle.pdf

Additional Readings and Resources

Introduction

Cultivating a next-generation classroom culture. NSTA Science Scope Teachers Toolkit. January 2014. By Chritina Krist, Lisa Brody, Michael Novak, and Keetra Tipton.

Observations and Questioning

The Driving Question Board. A Visual Organizer for Project Based Science. November 2008. By Ayelet Weizman, Yael Schwartz, David Fortus.

Scientific and Engineering Practices in K-12 Classrooms. Understanding A Framework for K-12 Science Education. NSTA *Science Scope.* December 2011. By Roger Bybee.

Modeling

Engaging Students in Scientific Practices: What does constructing and revising models look like in the science classroom? Understanding A Framework for K-12 Science Education. NSTA K-12 Journals. March 2012. By Joseph Kracik and Joi Merritt.

Carrying Out Investigations

The integral role of laboratory investigations in science instruction. NSTA Position Statement.

Explaining Evidence

Engaging Students in the Scientific Practices of Explanation and Argumentation. Understanding a Framework for K-12 Science Education. NSTA K-12 Journals April/May 2012 . By Brian Riser, Leema Berland, Lisa Kenyon.

Helping students write scientific explanations. NSTA Science Scope. September 2019. By Ann Novak, Katherine McNeill, and Joseph Krajcik.

Sharing Information

Exploring the Science Framework. Engaging Learners in the scientific practices of obtaining, evaluating and communicating information. NSTA Science Scope. November 2012 . By Philip Bell, Leah Bricker, Carrie Tzou, Tiffany Lee, and Katie Van Hone.

Talk Science Primer. TERC. 2012. By Sarah Michaels and Cathy O'Connor.

Appendix: Best Practices Tools (Full-Size)

MAKING OBSERVATIONS Tool

Start with a PHENOMENON

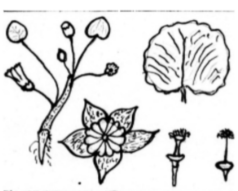
A demonstration (squid dissection)
A case study (monarch migration patterns)
A data set (sea surface temperatures)
Microscope work (tardigrades on lichen)
A photograph (double rainbow)
An x-ray (broken bone)

QUANTITATIVE
QUALITATIVE

Using your senses to describe or quantify what you observe

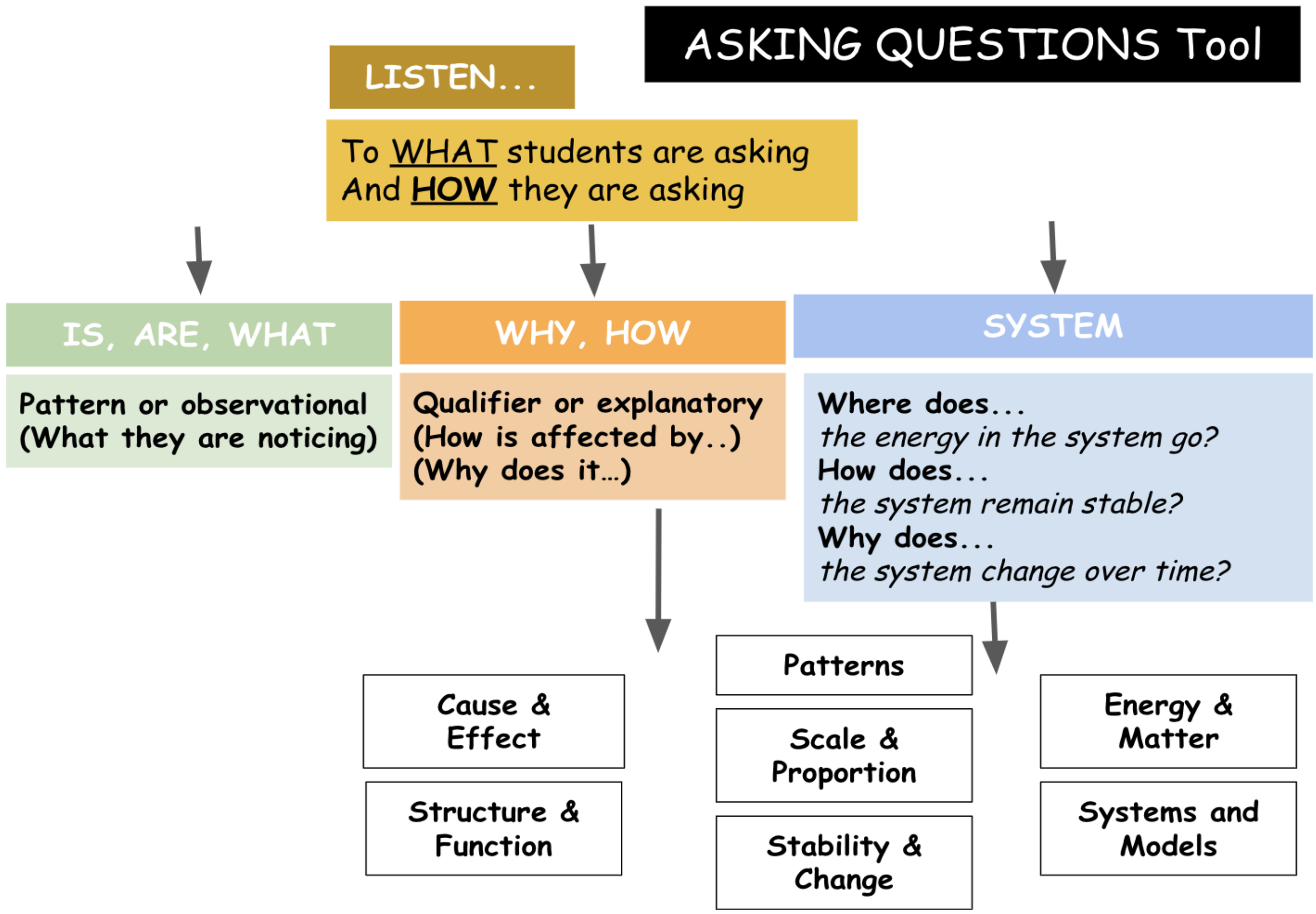
DETAILED

Be as descriptive as possible.
What you see AND what you don't see.
Draw or photograph with purpose.



ASK INVESTIGATIVE QUESTIONS RECORD THOSE QUESTIONS

What do I want to know about this that I'm seeing?


ASKING QUESTIONS Tool
LISTEN...
To WHAT students are asking
And HOW they are asking
IS, ARE, WHAT
Pattern or observational
(What they are noticing)
WHY, HOW
Qualifier or explanatory
(How is affected by..)
(Why does it…)
SYSTEM
Where does...
the energy in the system go?
How does...
the system remain stable?
Why does...
the system change over time?
Cause & Effect
Structure & Function
Patterns
Scale & Proportion
Stability & Change
Energy & Matter
Systems and Models

MAKING MODELS Tool

PHENOMENON

Observations

CONCEPTUAL MODEL

Initial ideas

GROUP CONSENSUS MODEL

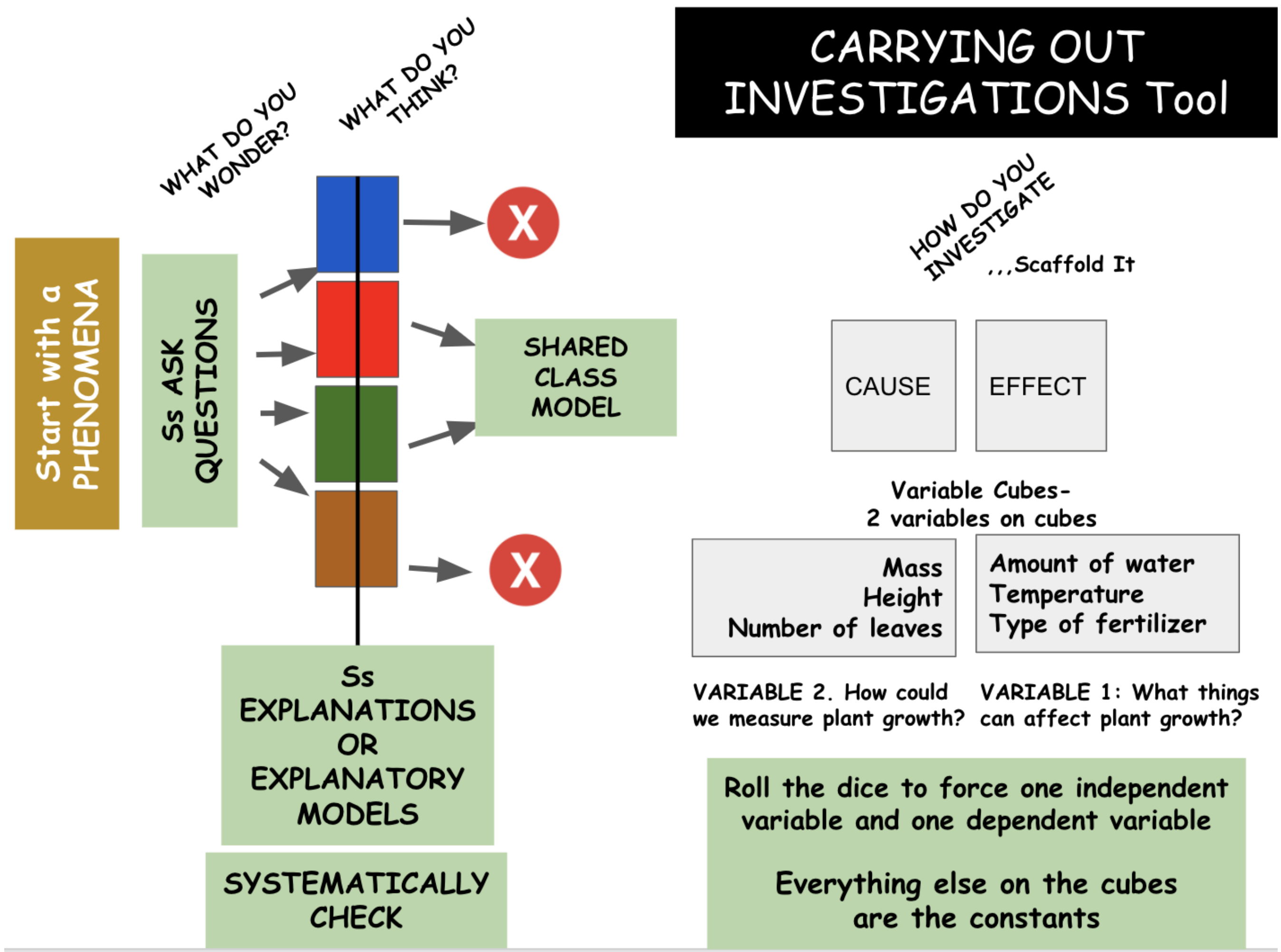
Shared agreements among 2-4 students

CLASS CONSENSUS MODEL

Shared agreements among entire class

WHAT MAKES A SCIENTIFIC MODEL

- Explanatory
- Components
  - Visible
  - Invisible
- Interactions between the components


CARRYING OUT INVESTIGATIONS Tool
Start with a PHENOMENA
Ss ASK QUESTIONS
WHAT DO YOU WONDER?
WHAT DO YOU THINK?
SHARED CLASS MODEL
Ss EXPLANATIONS OR EXPLANATORY MODELS
SYSTEMATICALLY CHECK
HOW DO YOU INVESTIGATE
...Scaffold It
CAUSE
EFFECT
Variable Cubes-
2 variables on cubes
Mass
Height
Number of leaves
Amount of water
Temperature
Type of fertilizer
VARIABLE 2. How could we measure plant growth?
VARIABLE 1: What things can affect plant growth?
Roll the dice to force one independent variable and one dependent variable
Everything else on the cubes are the constants

GOOD SCIENTIFIC QUESTIONS Tool

Identify the Nature of the Question

Observational- what do I notice?
Explanatory - how does it work?
System- what is happening? problem?

1. Does the question help us understand the phenomena ?

2. Can the question be empirically tested?

- observed ?
- experienced ?
- experimented ?

How do trees communicate?	OPEN
When is the best time to tap for sap?	CLOSED
Are there more old growth or new growth forests in Maine?	CLOSED
Is that caterpillar poisonous?	CLOSED
Why do the tides rise and fall?	OPEN

EXPLAINING EVIDENCE Tool

Explain the WHY and HOW

About the natural world and what causes natural phenomena(on)

CLAIM — Statement or answer to a question asked

EVIDENCE — Information (data) about the natural world used to support a claim

QUANTITATIVE

QUALITATIVE

ARGUE USING EVIDENCE

REASONING — Making a logical connection how your evidence supports your claim

COMPETITION

DIRECT/INDIRECT

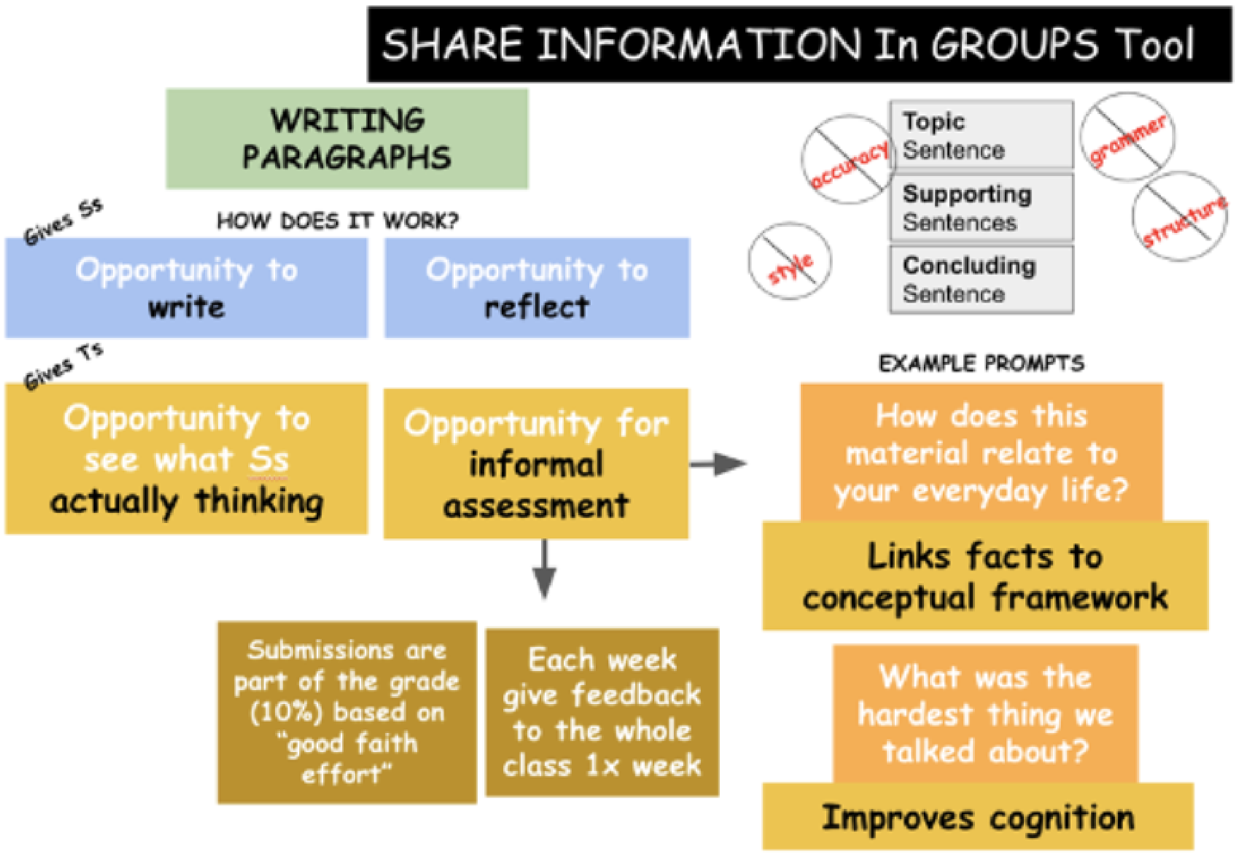
PREDATOR/PREY

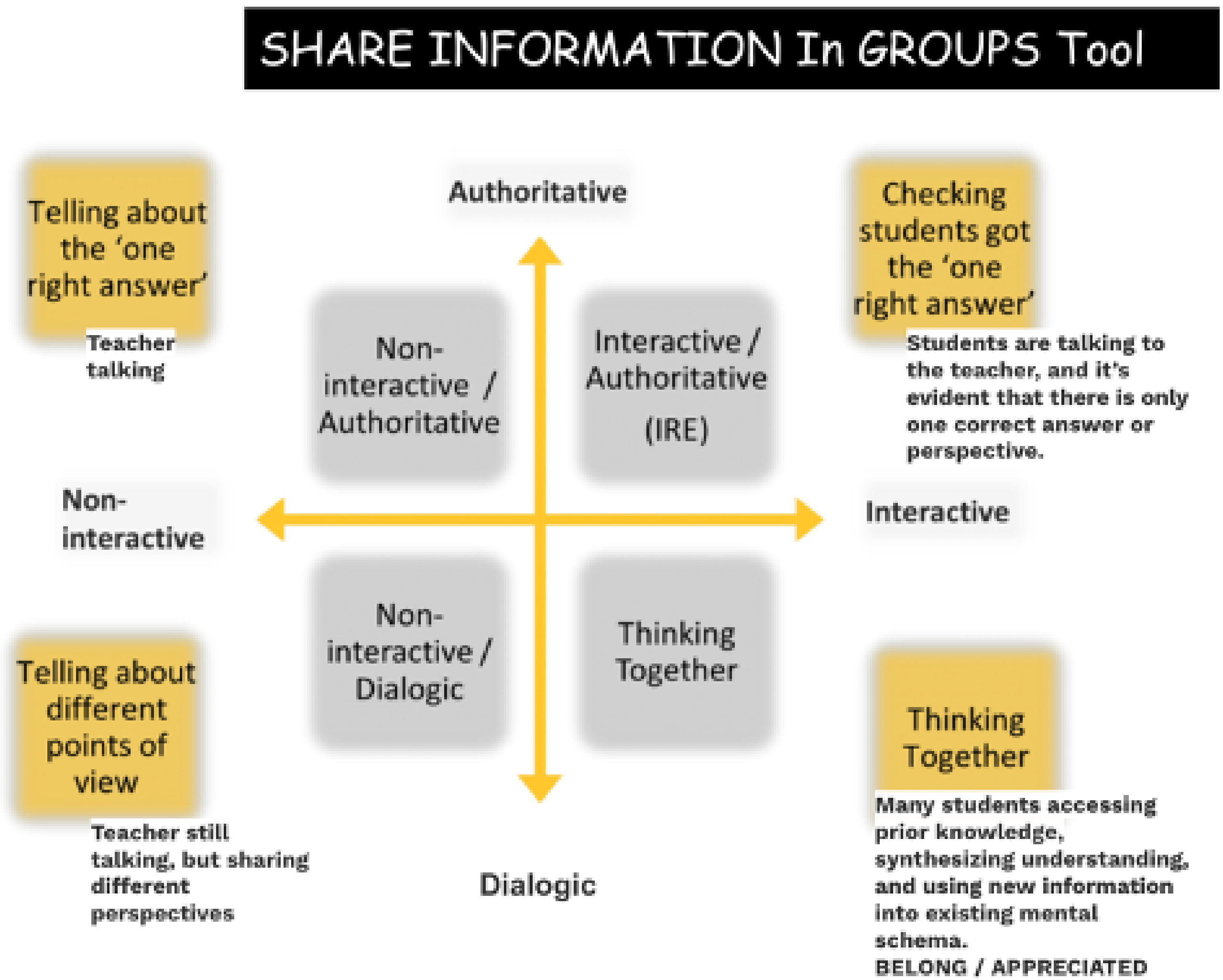
LIFE CYCLES

ABIOTIC/BIOTIC

PRODUCER/CONSUMER

SCIENTIFIC PRINCIPLES


SHARE INFORMATION In GROUPS Tool
WRITING PARAGRAPHS
HOW DOES IT WORK?
Gives Ss
Opportunity to write
Opportunity to reflect
Gives Ts
Opportunity to see what Ss actually thinking
Opportunity for informal assessment
Submissions are part of the grade (10%) based on "good faith effort"
Each week give feedback to the whole class 1x week
Topic Sentence
Supporting Sentences
Concluding Sentence
accuracy
grammer
structure
style
EXAMPLE PROMPTS
How does this material relate to your everyday life?
Links facts to conceptual framework
What was the hardest thing we talked about?
Improves cognition



Dialogic-authoritative dimensions of discourse on an interactive–non-interactive continuum (adapted from Mortimer & Scott, 2003, p. 35).

SHARE INFORMATION In GROUPS Tool

Tips to include voices

Anti-Proximity

When a student responds, move AWAY. Walk to the far side of the room. Now the conversation includes all of the students between the you and the student talking.

Body Language

Position your shoulders to open up and lift back toward the whole class rather than one student. Keep your head up as if you're looking at the far side of the room and scan the entire room will help signal to the students they are all expected to stay in the conversation.

Anonymous Input

Having a voice, sharing perspectives, externalizing thinking does not need to be traditional. Allow students to participate anonymously. NearPod - open ended and single/multiple response platform.Use of *Post-its* is also encouraged.

Thinking Routines

Think-pair-share and jigsaw routines allow for smaller group contribution where students feel more secure in sharing. Also, fishbowl triad discussion strategy is effective. Group students in 3 as they prepare for discussion. During actual discussion, there is an inner circle with only 1 rep from each triad. Students may tap in and out.

Adapted from TERC (2012), Talk Science in the Inquiry Project.

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