Putting together the “pieces” of NGSS into engaging learning experiences for all: The role of sense-making talk

Mark Windschitl & Caroline Hadley
University of Washington

https://education.uw.edu/people/faculty/mwind

Ice-breaker

• What is one instance you can remember of a student taking an idea from your science class, and trying it out at home? Experiment in the garage? Kitchen, Local park? How did you find out?

Who in your classroom participates?

- Can I participate?
- Will I participate?
- Can I see my interests in the science?
- Will people care about my ideas?

Standards, by themselves, have never changed “who gets to participate or how” in our classrooms

5 principles for expanding participation
Students motivated by events that are important, relevant, connected to events they’ve experienced or care about, problems that are interesting, realistic

Sophomore biology: Why did my aunt get breast cancer and will it spread?
2nd grade: An apple tree starts to grow on a hillside, where did it come from?
Kindergarten: How can someone little push someone big off the end of a slide?
AP Chemistry: Where did it come from?
8th grade: Why are killer whale populations in Puget Sound declining?
5th grade: Why are solar eclipses predictable and so rare?

Improving explanations: Add ideas & evidence, revise, get rid of ideas, pose new questions (learning how to learn)

Outcome of this work? Unique explanations & models
- Social behavior of wolves
- Eco disturbance
- Elk no longer trampling river banks
- Competition with coyotes
- Climate change

What the arc of a unit looks like...
Ecosystems: Yellowstone

Essential question: How could the re-introduction of a small number of wolves cause dramatic changes in the Yellowstone ecosystem?

- How social behavior helps survival
- Inter-dependence of different species
- Competition for resources
- Trophic pyramids: How does energy flow?
- Changing population data

Habitats
Carrying capacity

Have you used anchoring events? How did students respond?

OR

What local events or situations have the potential to be anchoring events?
**Principle 1 for expanding participation**

Create links between science topics and students’ everyday experiences, use their ideas as resources.

---

**Studying the “energy story” behind sound**

You will be 9th graders studying the “energy story” behind sound.

- I’ll frame the unit
- Introduce anchoring event
- Engage you in talk and activity that elicits your ideas and activates your prior knowledge
- You’ll make your thinking visible

---

Day 1

- I decided which standards would work well together for unit on sound
- Figured out an anchoring event and developed its explanation (see your handout)
- Planned out lessons that corresponded with standards and with parts of explanation

Took me 3 weeks of constant thinking about which ideas to teach, how, and how to integrate students’ everyday experiences in the curriculum.

---

DEVELOP 1 OR 2 GREAT UNITS A YEAR
Let's do some observations...

**BEFORE, DURING, AFTER**
- Before anything happened, I noticed this...
- While ___ was happening, I noticed this...
- After it happened, I noticed this...

**SAW, HEARD, FELT**
- I saw something happen...
- I heard this... it sounded like...
- I felt this...

**SHAPE, COLOR, SIZE**
- Something was this shape, this color, this size, it was in front of, it was behind...

**HOW FAST IT HAPPENED**
- Something happened slow...
- Something happened fast...

**SMALL DETAILS**
- I saw a detail, maybe it's not important but I want to state it anyway...
- Something seemed missing...

**OTHER?**
- Your choice!

Let's develop a list of “starter” ideas:
Under what conditions would the glass break?

- “We think it has something to do with _____.
- “We think ________ caused the glass to break.”
- “We are wondering ________.”

What talk moves should I use? See handout / See 4 posters.
Design safe spaces for talk in small groups and whole class settings.

"Between desks instruction”  Kikan-shidō

Talk moves...

**PROBING:** “What do you think about...?"  
**PRIMING:** “Would you be willing to share that idea?”  
**FOLLOW-UPS:** “Can you say more about that?”  
**REVOICING:** "What I think I hear you saying is..."  
**LEAVING QUESTION:** “What do you mean by sound dying out?”

Science modeling

Name:  
Date:  

1. "Between desks instruction”  Kikan-shidō

2. Design safe spaces for talk in small groups and whole class settings.

3. Talk moves...

4. Science modeling

5. "Between desks instruction”  Kikan-shidō

6. Design safe spaces for talk in small groups and whole class settings.

7. Talk moves...

8. Science modeling
BPQs (back pocket questions)

For students who are moving along:
- Can you share your thinking about THIS part of your model?
- Can you say more about what you think is happening HERE that we can't see?

For students who may be stalling out:
- Let's just say out loud what we saw and heard in the video, maybe that will jumpstart us.
- How do you think loud versus soft sounds are made?

Generic follow-ups:
- Can you say more about that? • Do you agree with your partner? • Do you want to add on? • Do you think that is important?
- Is there something you've seen or heard before outside of school that makes you say that?

Notes on which partners have ideas or questions that could be brought out to whole class?

Mark will demo this. This is in packet.

1. Listen first, ask question about what students already talking about
2. Use follow-ups, not one question after another
3. Don’t funnel students into using technical language or definition
4. Make eye contact with everyone, get students to comment on peers’ ideas
5. Ask a leaving question so they keep talking

What is your goal in this situation?

Plan now with partner, scribe use feedback sheet

Read your partner’s notes

• What questions or prompts generated the most reasoning, the most talk?
• What was unexpectedly challenging?
Inside Ashley’s 6th grade classroom

- Diverse urban K-8 school
- 80% Low income, 47% English Learners
- 20% Homeless

Modeling to make thinking visible: Is this share-out more than just sharing?

- How might the teacher framing be thought of an equity move—increasing participation?
- Are there ideas or puzzlements from Kelanie that could be used as resources for reasoning by her peers?

Principle 3 for expanding participation

- Make student thinking visible, use multiple modalities
- Encourage drawing + talking + gesturing + writing
Day 3

Compression waves:
- There are some science ideas students cannot “discover”
- We might use interactive direct instruction followed by lab activity to teach this idea

Decibels as a measure of sound intensity

<table>
<thead>
<tr>
<th>Source</th>
<th>Intensity</th>
<th>Intensity Level</th>
<th>Intensity Level Scale</th>
<th># of Times Greater Than TON</th>
<th>Entry task: Which air particle representation matches with the origin of the sound? Each shows number of waves in one second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold of Hearing (THI)</td>
<td>1 \times 10^{-12} W/m²</td>
<td>0 dB</td>
<td>10^0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rustling Leaves</td>
<td>1 \times 10^{-11} W/m²</td>
<td>10 dB</td>
<td>10^1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whisper</td>
<td>1 \times 10^{-10} W/m²</td>
<td>20 dB</td>
<td>10^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Conversation</td>
<td>1 \times 10^{-9} W/m²</td>
<td>40 dB</td>
<td>10^4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Busy Street Traffic</td>
<td>1 \times 10^{-8} W/m²</td>
<td>70 dB</td>
<td>10^6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum Cleaner</td>
<td>1 \times 10^{-7} W/m²</td>
<td>90 dB</td>
<td>10^8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Orchestra</td>
<td>6.3 \times 10^{-6} W/m²</td>
<td>99 dB</td>
<td>10^11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wallum at Maximum Level</td>
<td>1 \times 10^{-5} W/m²</td>
<td>100 dB</td>
<td>10^14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front Rows of Rock Concert</td>
<td>1 \times 10^{-4} W/m²</td>
<td>110 dB</td>
<td>10^17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold of Pain</td>
<td>1 \times 10^{-3} W/m²</td>
<td>130 dB</td>
<td>10^20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Military Jet Takeoff</td>
<td>1 \times 10^{-2} W/m²</td>
<td>140 dB</td>
<td>10^23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instant Perturbation of Eardrum</td>
<td>1 \times 10^{-1} W/m²</td>
<td>160 dB</td>
<td>10^26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The green grocer cicada produces 120 dB chirps at close range.

Elephants make such loud rumbles “they literally make your body vibrate.” The sound can be “deafening,” 105 dB measured at five meters.

The bulldog bat has been recorded crying at 140 dB as it hunts over lakes in Panama. Beyond our hearing at an ultrasonic 55 kHz.

Sperm whale communicative clicks have been measured at 230 dB. Divers nearby have their bodies heated up and have to leave the water.
Improving our models by designing investigations: How can we test one of the uncertainties we have below?

- Your models showed uncertainty about whether sound “dies out” in energy over distance
- About whether sound moves in one direction from its source

Phone apps accurate within 5 decibels of professional equipment

1. What are we interested in finding out? Write two full sentences please.

2. What will the results tell us about our model of the singer and glass? Write two full sentences please.

3. How will we collect data in a systematic way? Write two full sentences please.

4. Procedures: Here’s what we’ll do, step-by-step. Write in detail so someone else could read this and reproduce your experiment. Include materials.

5. What do we think we know as a result of our experiment and the experiments of our classmates?

6. What questions are we left with?

Data Table

<table>
<thead>
<tr>
<th>Distance (meters)</th>
<th>In front of horn</th>
<th>In back of horn</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Record class data in table: put a comma between readings from different groups at the same location.

Designing an investigation

- What are we interested in finding out? Write two full sentences please.

- What will the results tell us about our model of the singer and glass? Write two full sentences please.

- How will we collect data in a systematic way? Write two full sentences please.

- Remember, there’s data we’ll be keeping super-secret. Write in exactly the same way that you will use this and reproduce your experiment. Include materials.

- What do we think happened that we couldn’t directly observe? Draw and label.

- Student-created data display
Day 6

How can we represent our data in ways that help us make sense of it?

Different kinds of models emphasize different ideas, relationships

Our Summary Table

<table>
<thead>
<tr>
<th>Activity</th>
<th>Observations?</th>
<th>What caused those?</th>
<th>How does it explain the shattering glass?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency and amplitude</td>
<td>Oscilloscope showed string vibrated at higher freq when tightened, more times per second. Higher pitch.</td>
<td>Bow makes string vibrate, which makes air vibrate too at same freq. We hear it as higher pitch when more waves per second. Amp is just volume.</td>
<td>Singer makes different pitches, making air vibrate at different waves per second.</td>
</tr>
<tr>
<td>Compression waves</td>
<td>Push on slinky makes coil &quot;crunch together,&quot; the compressed part moves down the slinky.</td>
<td>Must be different kinds of waves, some are up-down (like water), some are dominoes that push a wave of energy from one pace to another. &quot;The wave&quot; in stadium.</td>
<td>If sound is compression, glass is getting hit with waves of particles that have been pushed together. What is amp?</td>
</tr>
<tr>
<td>Decibels at a distance study</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resonance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this video...

- Who has opportunities to talk in this routine?
- What groundwork for talk has likely been laid by the teacher earlier this year? Is there scaffolding or structuring of this conversation that you see evidence for?
Principle 4 for expanding participation

Provide opportunities for students to use new academic language in the context of science conversations (don’t front-load vocabulary).

Using the “small conversation space” of a warm up to help demystify argumentation

I think that our experiment shows sound energy moves out in all directions.

Our experiment showed that the decibel reading right next to the horn was 100.

Claim: statement about a process or event that can explain patterns in observations or data

Student A
Student B

Is student “A” stating a scientific claim? Say why you think so, or not.

Is student “B”? Say why you think so, or not.

Revising models: How has our thinking changed?

Revise: We think [evidence from activity/reading] supports PART of our model, but we want to change _____ to make it more accurate.

Add: We think [evidence from summary table] supports PART of our model, but we want to add _____ to make it more accurate.

Remove or find out more: We think [evidence from activity/reading] contradicts _____ in our model, and we want to remove it or find out more about it.

Questions: We still have questions about _____.

Ensemble of practices = Investigation + modeling + arguing from evidence (scaffolding how to change models in response to evidence)
Using evidence to improve our initial list of ideas?

1. Select one hypothesis or “hunch,” decide whether we should:
   • Get rid of it
   • Add something to it
   • Connect it to another one
2. Should we add any other hypotheses?
3. Should we put these in order of when we think they happened?

Resonance

<table>
<thead>
<tr>
<th>Activity</th>
<th>Observations?</th>
<th>What caused those?</th>
<th>How does it explain the shattering glass?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency and amplitude</td>
<td>Oscilloscope showed string vibrated at higher freq when tightened, more times per second. Higher pitch.</td>
<td>Bow makes string vibrate, which makes air vibrate too at same frequency. We hear it as higher pitch when more waves per second. Amp is just volume.</td>
<td></td>
</tr>
<tr>
<td>Compression waves</td>
<td>Push on slinky makes coil “crunch together,” the compressed part moves down the slinky.</td>
<td>Must be different kinds of waves, some are up-down (like water), some are dominoes that push a wave of energy from one pace to another.</td>
<td></td>
</tr>
<tr>
<td>Decibels at a distance study</td>
<td>Sound seems to go out like a circle in all directions from source. Sound “dies out” over distance.</td>
<td>Sound compression waves must spread energy over bigger circles, like waves in a pond. Energy in any one place less if it is a bigger circles (farther away).</td>
<td></td>
</tr>
<tr>
<td>Resonance</td>
<td>Tuning fork vibrates at only one frequency, like wine glass can only do one.</td>
<td>One tuning fork can make another one vibrate because it creates compression waves at same rate that the other one vibrates at.</td>
<td></td>
</tr>
</tbody>
</table>

Make explicit 1) the structure of authentic science practices, 2) “hidden rules” about science talk.

Principle 5 for expanding participation

Our Summary Table
The question we are answering by drawing this model and writing our explanations: How did this singer break the glass with his voice?

Directions:
1. In the three panels below, draw what is happening that you can and cannot see that is causing the glass to shatter. USE ZOOM-INS.

2. Use the drawings to help you write an explanation about what is happening at each point in time.

3. For each picture, be sure to include the ideas from the Gotta-Have Checklist:
   - How compression waves move energy
   - How frequency and amplitude play a role in the glass breaking
   - The full story of energy transfers from person to glass
   - How resonance plays a role in the story

4. After completing your model, provide evidence from one class activity that supports one of your claims. Write the evidence on a sticky note and place on the relevant drawing.

Names: ____________________________

Period: __________________________

Expanding opportunities to be smart
1. Create links between science topic and students’ everyday experiences, use their ideas as resources.
2. Make student thinking visible, use multiple modalities.
3. Make explicit 1) the structure of authentic science practices, 2) “hidden rules” about science talk.
4. Provide opportunities for students to use new academic language in the context of science conversations (don’t front-load vocabulary).
5. Design safe spaces for talk in small groups and whole class settings.

End of unit: Transferring knowledge to new situation