Ambitious Science Teaching

Supporting Engagement and Sense-making Opportunities for All Our Students

Mark Windschitl
University of Washington

What’s the knowledge base for our profession?

...and networks of practitioners

Engagement: 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 does the heat go when I pour out my coffee?

5th grade: Why are solar eclipses predictable and so rare?

8th grade: Why are killer whale populations in Puget Sound declining?

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

What the arc of a unit looks like...

Ecosystems: Yellowstone

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

Principle 1 for expanding participation

Have you used anchoring events? How did students respond?

OR

What local events or situations have the potential to be anchoring events?
Studying the “energy story” behind sound

DEVELOP 1 OR 2 GREAT UNITS A YEAR

• 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.

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
• Support authentic science practice and reasoning
Let's do some observations...

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.

Science modeling

Draw or write about something in your life that reminds you of.

What questions do you have?
“Between desks instruction”  

Kikan-shidō

180 seconds

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?”

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

How we’ll run the simulation rounds ~ 5 minutes each

Round 1
1s play role of teacher, moves to the next table clockwise.
2s accompany the 1s, play role of scribe, record what is said by everyone at the table after 1s start.

Round 2
3s play role of teacher, moves to the next table clockwise.
4s accompany the 3s, play role of scribe, record what is said by everyone at the table after 3s start.
Round 3
2s play role of teacher, moves to the next table clockwise. 1s accompany the 2s, play role of scribe, record what is said by everyone at the table after 2s start.

Round 4
4s play role of teacher, moves to the next table clockwise. 3s accompany the 4s, play role of scribe, record what is said by everyone at the table after 4s start.

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 as 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

3 Make student thinking visible, use multiple modalities

Encourage drawing + talking + gesturing + writing

AP Chem: Where does heat go in my coffee?

How can we stop a hurricane? (6th)
Posterizing = not modeling

- Nothing puzzling or complex
- Has a “correct answer”
- Everyone’s representations look the same

Is this beautiful and detailed drawing an example of posterizing?

Why can do few wolves change the Yellowstone ecosystem?
Consensus model by kindergarteners: How can someone little bump someone big off the end of a playground slide?

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># of Times Greater Than TOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold of Hearing (TOH)</td>
<td>$1 \times 10^{-12}$ W/m²</td>
<td>0 dB</td>
<td>$10^0$</td>
</tr>
<tr>
<td>Rustling Leaves</td>
<td>$1 \times 10^{-11}$ W/m²</td>
<td>10 dB</td>
<td>$10^1$</td>
</tr>
<tr>
<td>Whisper</td>
<td>$1 \times 10^{-10}$ W/m²</td>
<td>20 dB</td>
<td>$10^2$</td>
</tr>
<tr>
<td>Normal Conversation</td>
<td>$1 \times 10^{-9}$ W/m²</td>
<td>60 dB</td>
<td>$10^4$</td>
</tr>
<tr>
<td>Busy Street Traffic</td>
<td>$1 \times 10^{-8}$ W/m²</td>
<td>70 dB</td>
<td>$10^7$</td>
</tr>
<tr>
<td>Vacuum Cleaner</td>
<td>$1 \times 10^{-7}$ W/m²</td>
<td>80 dB</td>
<td>$10^8$</td>
</tr>
<tr>
<td>Large Orchestra</td>
<td>$6.3 \times 10^{-3}$ W/m²</td>
<td>98 dB</td>
<td>$10^{13}$</td>
</tr>
<tr>
<td>Walkman at Maximum Level</td>
<td>$1 \times 10^{-2}$ W/m²</td>
<td>100 dB</td>
<td>$10^{10}$</td>
</tr>
<tr>
<td>Front Rows of Rock Concert</td>
<td>$1 \times 10^{-1}$ W/m²</td>
<td>110 dB</td>
<td>$10^{11}$</td>
</tr>
<tr>
<td>Threshold of Pain</td>
<td>$1 \times 10^{-1}$ W/m²</td>
<td>130 dB</td>
<td>$10^{13}$</td>
</tr>
<tr>
<td>Military Jet Takeoff</td>
<td>$1 \times 10^{-1}$ W/m²</td>
<td>140 dB</td>
<td>$10^{14}$</td>
</tr>
<tr>
<td>Instant Perforation of Eardrum</td>
<td>$1 \times 10^4$ W/m²</td>
<td>160 dB</td>
<td>$10^{16}$</td>
</tr>
</tbody>
</table>

For a sound to be measured with sensitive instrumentation, the decibel rating is determined by the intensity of the sound. The Decibel Calculator can be used to enter the intensity of a sound in W/m² and determine the decibel level. For example, a sound that is 10*10 or 100 times more intense (1*10^2) is assigned a sound level of 20 dB. A sound that is 10*10*10*10 or 10000 times more intense (1*10^5) is assigned a sound level of 30 db. A sound that is 10*10 or 100 times more intense (1*10^2) is assigned a sound level of 10 dB. A sound that is 10*10*10 or 1000 times more intense (1*10^3) is assigned a sound level of 15 db. A sound that is 10*10*10*10 or 10000 times more intense (1*10^4) is assigned a sound level of 20 db.

Decibels are a measure of sound intensity used in the context of expanding participation in science conversations. Decibels are frequently used by physicists to measure intensity. The scale for measuring intensity is a logarithmic scale. This type of scale is sometimes referred to as a decibel scale and is based on powers of 10.

Threshold of Hearing (TOH) and the threshold of pain are assigned to 0 and 120 decibels (dB) respectively. The most intense sound that the ear can safely detect without suffering any physical damage is more than one billion times more intense. The table lists common sounds with an estimate of their intensity and decibel level.

Note: For additional information, visit http://www.physicsclassroom.com/Class/sound/u11l2b.cfm

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).
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

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?

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 that 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?

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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>
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</table>

Record class data in table: put a comma between readings from different groups at the same location.
Day 6

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

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 some frequency. 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>
</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?
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.

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

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

Ensemble of practices = Investigation + modeling + arguing from evidence (scaffolding how to change models in response to evidence)

Revising models: How has our thinking changed?

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

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

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

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

Questions: We still have questions about [evidence from activity/reading].

Principle 5 for expanding participation

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

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</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>Guy should be close to glass to break it, otherwise his sound energy is spread out.</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>Singer has to tap glass to know its frequency. His vocal cords and brain match the frequency to sing at the glass.</td>
</tr>
</tbody>
</table>

The question we are answering by drawing this model and writing our explanations: How did the 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.

End of unit: Transferring knowledge to new situation
Expanding opportunities to be smart

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