Formative Assessment in Inquiry Science

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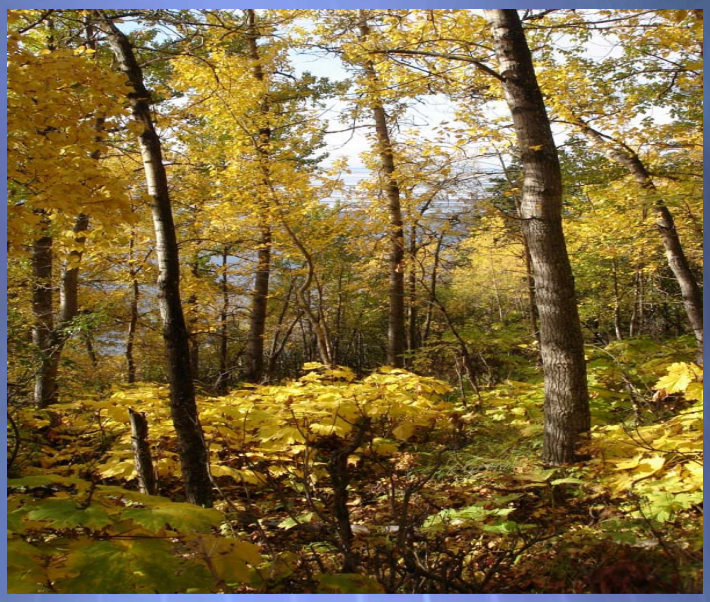
Anchorage, Alaska
September 10, 2009
Monterrey, Mexico

Gracias

Gracias



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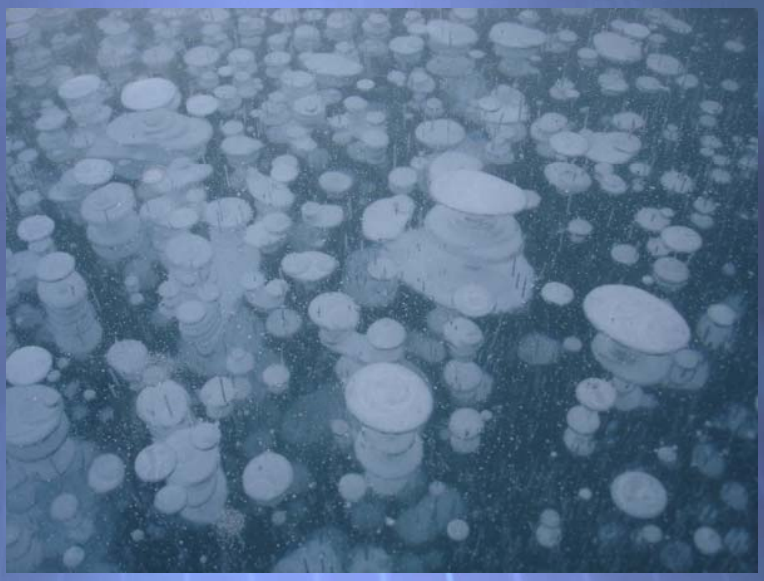

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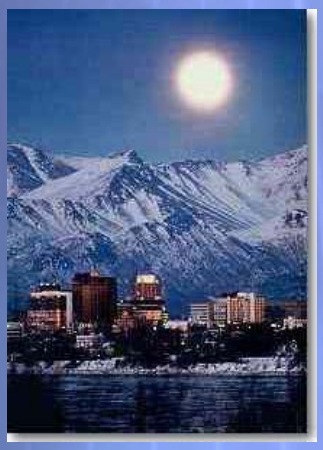
Anchorage School District



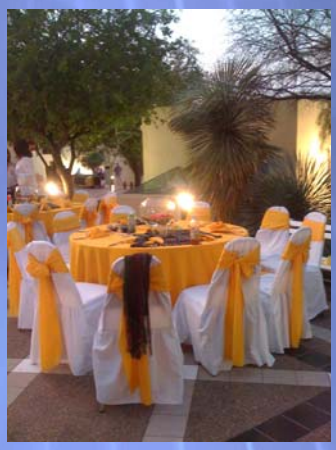
- 260,000 population
- 56,000 students K - 12
- 64 elementary, 10 middle, 10 high schools
- urban/suburban

Set Up Your Notebook

- Cover
- Title Page
- Table of Contents
- Resources
  Glossary, Bibliography, References
- Page turner
- Magic Paper

Resources

- herminghaus_trisha@asdk12.org



Workshop Goals

- Discuss formative assessment and the implications for increasing student learning
- Examine assessment probes
- Experience formative assessment classroom techniques
- Research on feedback

Agenda

- Set up science notebooks
- Agenda review
- Types of assessment
- Assessment probes
- Inquiry w/ embedded assessment strategies
- Formative assessment strategy review
- Research
- Assessing student notebooks

Quiet Signal

- Finish sentence
- Shift focus to speaker
- 16 - 18 teaching days regained!!!

Take Off, Touch Down

- Un professor de la escuela elementario
- Un professor de la secondario
- Un professor de la universidad
- Especialista de educacion ciencia
- Coordinar de ciencia
- Principal
- Director

How do you assess student understanding?

- In your science notebook, please record the ways you assess student understanding.
  - before a unit
  - during a unit
  - after a unit
- Be prepared to share

Traveling Pair Share

- Introduce yourself and share ideas you have for assessing students.
- Thank your partner.
- Hand-Up to find a new partner!

Assessment

- Diagnostic
  - identify preconceptions
  - lines of reasoning
  - learning difficulties

Assessment

- Formative
  - minute by minute, day by day
  - informs instruction
  - provides feedback to students about their learning

Assessment

- Summative
  - to measure and document the extent to which students have achieved a learning target
  - report out to students, parents, schools, districts

Assessment

- Formative Assessment Informs Teaching:

- teacher continuously gathers information on student thinking
- makes data-informed decisions
- adjusts instruction accordingly
- monitors pace of instruction
- identifies potential misconceptions
- spends additional time on ideas with which students struggle

Page Keeley

Research

- Principal 1
  - if initial understanding is not engaged, students may fail to grasp concepts
  - may learn for test but revert to initial ideas after

Research

- Principal 2
  - students must have deep foundation in factual knowledge, understand facts and ideas in context of conceptual framework
  - organize knowledge in ways that facilitate retrieval (scaffolding)
  - may learn for test but revert to initial ideas after

Research

- Principal 3
  - a metacognitive approach to learning helps students take control of their own learning

Assessment Probes

Assessment Probes

- Used before or during instruction
- Assess student ideas and reasoning
- Powerful
- Find a way to have them translated
- Write them to fit your curriculum

Assessment Probes

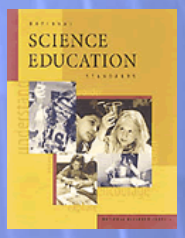
- Two-tiered

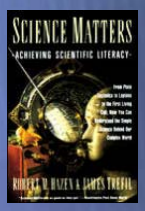
  - one tier is best answer selected by the student

  - second tier is students reasoning for selecting a response

Resources

★ 

★ 



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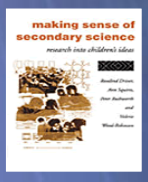
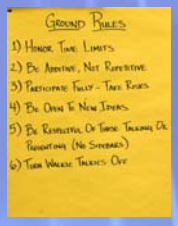


★ Indicates the resource or parts of it are online

Step 1

Establish Group Norms

Generate norms or "ground rules" for conducting the CIEST protocol



* Include sticking to the protocol!

Step 2

Examine and Complete the Probe

Jot down any notes about:

- Prior knowledge you accessed (formal or informal knowledge)
- Any difficulties you encountered or content you are unsure of
- How and when your students might have encountered (or will encounter) the concept targeted in this probe

Mixing Water

Melinda filled two glasses of equal size half-full with water. The water in one glass was 50 degrees Celsius. The water in the other glass was 10 degrees Celsius. She poured one glass into the other, stirred the liquid, and measured the temperature of the full glass of water.

What do you think the temperature of the full glass of water will be? Circle your prediction.

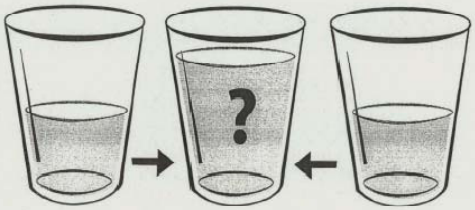
A 20 degrees Celsius

B 30 degrees Celsius

C 40 degrees Celsius

D 50 degrees Celsius

E 60 degrees Celsius



Explain your thinking. Describe the "rule" or reasoning you used for your answer.

Step 3

Probe Clarification and Standards Groundwork

- What concept or idea is this probe trying to "uncover"?
- What is the "best" answer to the probe?
- How would you explain the answer?
- What specific ideas from national and state standards are related to this probe?

Curriculum Topic Study Heat and Temperature

- Group conducts study on Heat and Temperature to learn the specific ideas from the national standards as well as related learning goals from their state standards.

Step 4

Anticipate Student Thinking

How might a heterogeneous class of Grade 8 students respond to the *Mixing Water probe*?

Share one assumption based on knowledge of your own students or other experiences.

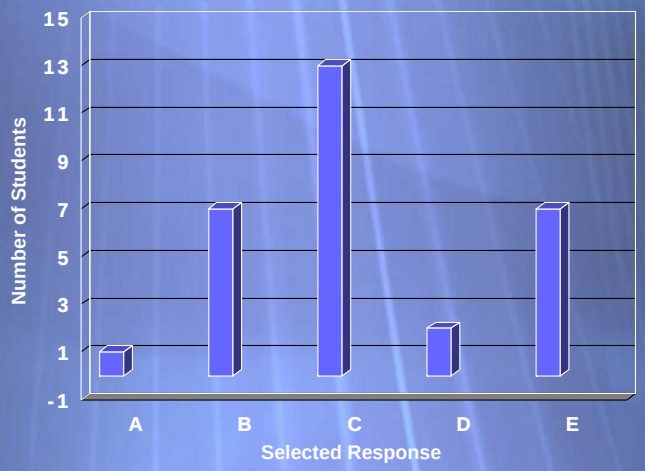
Step 5

Organizing Data

Sorting Responses

- Sort papers by response.
- Tally the Tier 1 responses (forced-choice responses).
- Go Visual! Create a bar graph of students' responses.

Grade 8 Results (30 students)



Step 5 (Cont'd)

Organizing Data

Task 2: Organizing Reasoning

- Examine the student's reasoning for each selected response. Form categories of reasoning.
- Match the student responses with the reasoning category.
- Go Visual!- Create a graph, chart, or other type of display that will help others understand students' thinking related to the answers they selected.

?Esta Claro?

- Fist - no understanding
- 1 Finger - very little understanding
- 2 Fingers - I understand parts of it, but I need a lot of help
- 3 Fingers - I understand most of it but I'm not sure I can explain it to others
- 4 Fingers - I understand it pretty well and can explain most of it
- 5 Fingers - I understand it completely and can easily explain it to others

Fist to Five

Step 6

Analyzing the Data

- What commonly held student ideas do you see when looking at the data?
- Do any patterns or trends emerge from the data?
- What are some surprising or interesting findings?

Step 7

Examine Cognitive Research

- Highlight sections of the research related to the commonly held ideas in the student work.
- Share research findings that appear to match findings from your data.
- Note any common ideas not described in the research that you found in your student work.
- Note any idiosyncratic ideas worth considering.

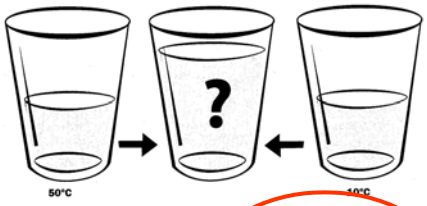
- Are there any ideas in the "steps along the way" that the students' may have missed?
- Are there suggestions for effective instruction that you should take into account with these students?
- What implications does this have for curriculum?

Individual Reflection

- What will you do with the information you gained?
- What did you gain by examining student thinking with your colleagues?
- What would you like to try differently in your classroom or in your professional learning communities as a result of this experience?

Mixing Water

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about temperature and energy transfer. The probe is designed to find out whether students recognize that a transfer of energy from the warm water to the cool water occurs until they reach the same temperature. Additionally, students' explanations reveal whether they use an addition, subtraction, or averaging strategy to determine the resulting temperature.

Related Concepts

conduction, energy, energy transfer, heat, temperature

Explanation

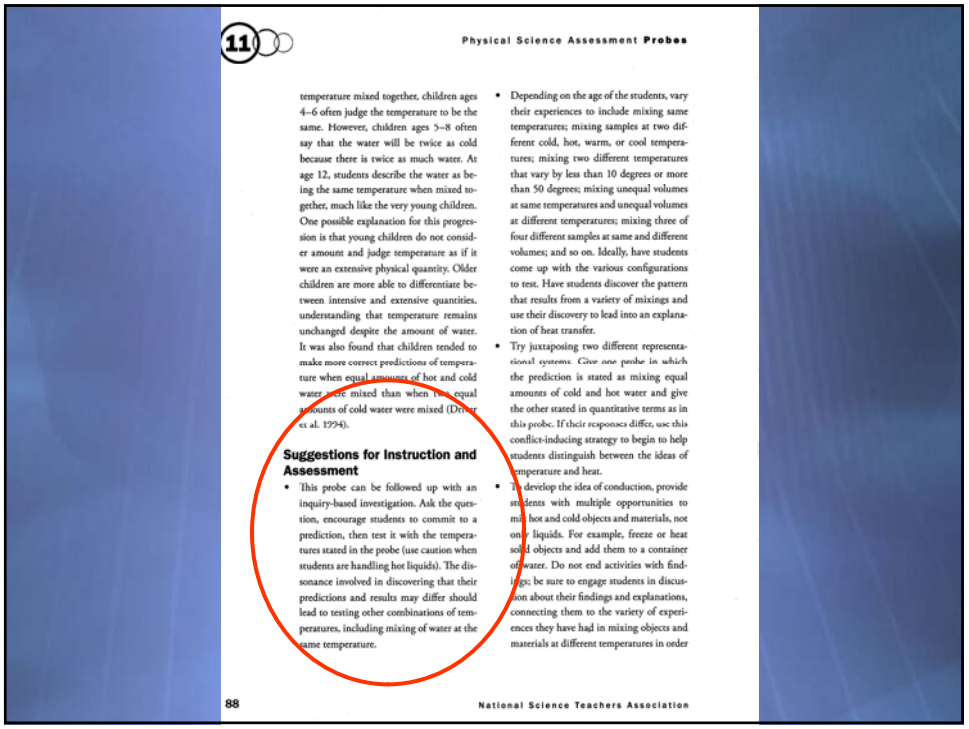
The best response is B: 30°C. (In actuality it would be slightly less, because a small amount of heat energy is transferred from the water to the glass and the surrounding environment in the process.) Temperature is a measure of the average motion of the particles that make up the water. The two separate samples of water are at different temperatures, meaning the average energy of the particles is less in the cooler (10°C) sample. When the cooler water and the warmer water are mixed together, a transfer of energy (conduction) occurs between particles when they come in contact with each other. The flow of heat moves from the molecules

other places or forms increases by the same amount.

★ Heat energy in a material consists of the disordered motions of its atoms or molecules. In any interactions of atoms or molecules, the statistical odds are that they will end up with less order than they began—that is, with the heat energy spread out more evenly.

Related Research

- Middle school students often do not explain the process of heating and cooling in terms of heat being transferred. When transfer ideas are involved, some students will think that cold is being transferred from a colder to warmer object. Other students think that both heat and cold are transferred at the same time (AAAS 1993).
- Middle and high school students do not always explain heat-exchange phenomena as interactions. For example, students may describe objects as tending to cool down or release heat spontaneously without acknowledging that the object has come in contact with a cooler object or area (AAAS 1993).
- Numerous studies have shown that few middle and high school students understand the molecular basis of heat transfer after instruction. Difficulties in understanding remain even with instruction that is specially designed to explicitly address the difficulty of understanding heat transfer (AAAS 1993).
- Researchers have found that difficulties experienced by students in response to questions that ask them to predict the final temperature of a mixture of two quantities of water, given the initial temperature of the components, depend on the form in which the temperature problems are presented. Qualitative tasks in which the water is described as warm, cool, hot, or cold are easier than quantitative ones in which specific temperatures are given. The mixing of waters at different temperatures (e.g., hot and cold or 30°C and 80°C) is more difficult than mixing water at the same temperature (e.g., warm and warm or 50°C and 50°C). It is not until around the age of 12 that most students can predict quantitatively what will happen in the type of problem posed in this probe (Erickson and Tiberghien 1985).
- Student responses to tasks similar to the one posed in this probe have been categorized according to the strategy used. Younger students (ages 8–9) prefer an addition strategy, whereas older students are more apt to use a subtraction strategy, which at least acknowledges that the final temperature lies somewhere in between. However, students ages 12–16 were as likely to use an addition or subtraction strategy as to use an averaging strategy (Erickson and Tiberghien 1985).
- When considering the final temperature of two beakers of cold water at the same



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Physical Science Assessment Probes

temperature mixed together, children ages 4–6 often judge the temperature to be the same. However, children ages 5–8 often say that the water will be twice as cold because there is twice as much water. At age 12, students describe the water as being the same temperature when mixed together, much like the very young children. One possible explanation for this progression is that young children do not consider amount and judge temperature as if it were an extensive physical quantity. Older children are more able to differentiate between intensive and extensive quantities, understanding that temperature remains unchanged despite the amount of water. It was also found that children tended to make more correct predictions of temperature when equal amounts of hot and cold water were mixed than when two equal amounts of cold water were mixed (Driver et al. 1994).

Suggestions for Instruction and Assessment

- This probe can be followed up with an inquiry-based investigation. Ask the question, encourage students to commit to a prediction, then test it with the temperatures stated in the probe (use caution when students are handling hot liquids). The dissonance involved in discovering that their predictions and results may differ should lead to testing other combinations of temperatures, including mixing of water at the same temperature.
- Depending on the age of the students, vary their experiences to include mixing same temperatures; mixing samples at two different cold, hot, warm, or cool temperatures; mixing two different temperatures that vary by less than 10 degrees or more than 50 degrees; mixing unequal volumes at same temperatures and unequal volumes at different temperatures; mixing three of four different samples at same and different volumes; and so on. Ideally, have students come up with the various configurations to test. Have students discover the pattern that results from a variety of mixings and use their discovery to lead into an explanation of heat transfer.
- Try juxtaposing two different representational systems. Give one probe in which the prediction is stated as mixing equal amounts of cold and hot water and give the other stated in quantitative terms as in this probe. If their responses differ, use this conflict-inducing strategy to begin to help students distinguish between the ideas of temperature and heat.
- To develop the idea of conduction, provide students with multiple opportunities to mix hot and cold objects and materials, not only liquids. For example, freeze or heat solid objects and add them to a container of water. Do not end activities with findings; be sure to engage students in discussion about their findings and explanations, connecting them to the variety of experiences they have had in mixing objects and materials at different temperatures in order

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National Science Teachers Association

Sound Exploration

Complete the assessment probe about Sound.

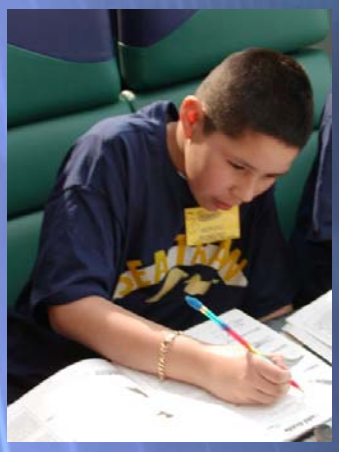
Sound Exploration

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Record your observations, questions and ideas in your notebook as you explore sound.

Saving Space

- In your notebook, on the first blank page, fold over the right edge of the page about one inch from the edge of the page.



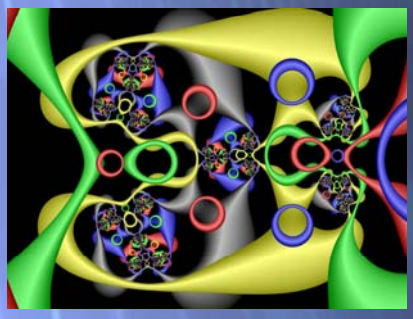
Sound Exploration Task

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

- Arrange the rubber bands and golf tees on the pegboard.
- Investigate the sounds the rubber bands make.
- Be prepared to share what you discover.

Sound Exploration Task

- Using the golf tees and rubber bands, explore the relationship between tension and pitch.
- Record your ideas and information about your exploration as you work.



Sound Exploration Task

- Explore how vibrations are related to pitch and tension. Record the results of your investigation as you proceed.

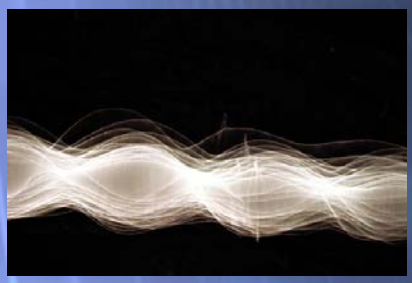
Scaffolding

- When I did _____, _____ happened.

  I think this is because_____ .

Share Notebook Entry

- Find a Partner
- Share with your partner what you discovered about the relationship between tension, pitch, and the vibrations of the rubber bands.



Share Notebook Entry

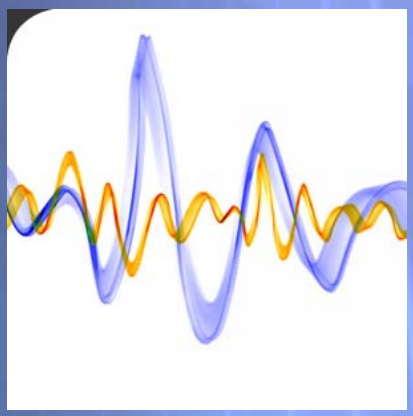
- Now…
  - ✓Share with the same partner how you recorded your information.

$$f = \frac{1}{T} = \frac{\omega}{2\pi}$$

Share Notebook Entry

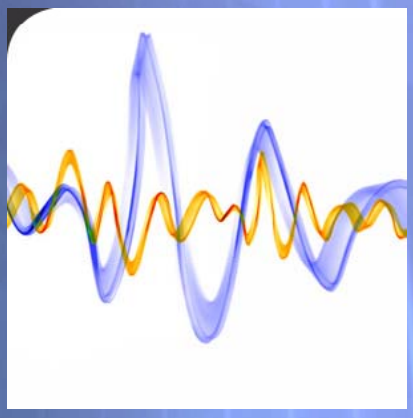
- Find Another Pair:
  - ✓Pairs Compare
  - ✓Round Robin
- Share between the pairs what ideas you recorded and how you organized your information.

Thinking About Sound



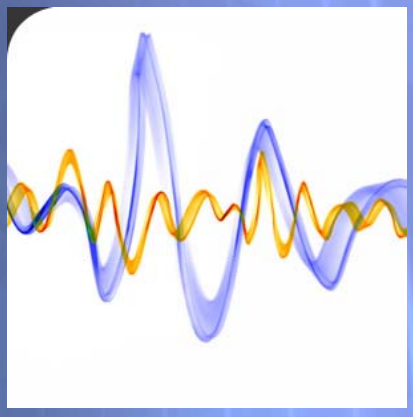
- Create a drawing that shows something you know about sound after today's explorations.

Thinking About Sound



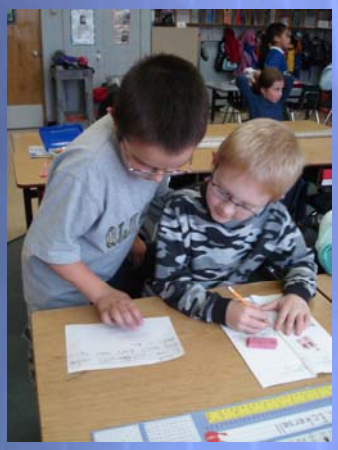
- Write an explanation of what your drawing is showing us.

Thinking About Sound



- Share your drawing and your explanation with someone sitting near you.

Coding Your Entries



! Interesting!
? Question
Remember
☺ This was fun!
√ Come back to this
etc.

Multiple Choice

✦Things that make sound_____ .

A. are hard when you touch them

B. have moving parts

C. vibrate

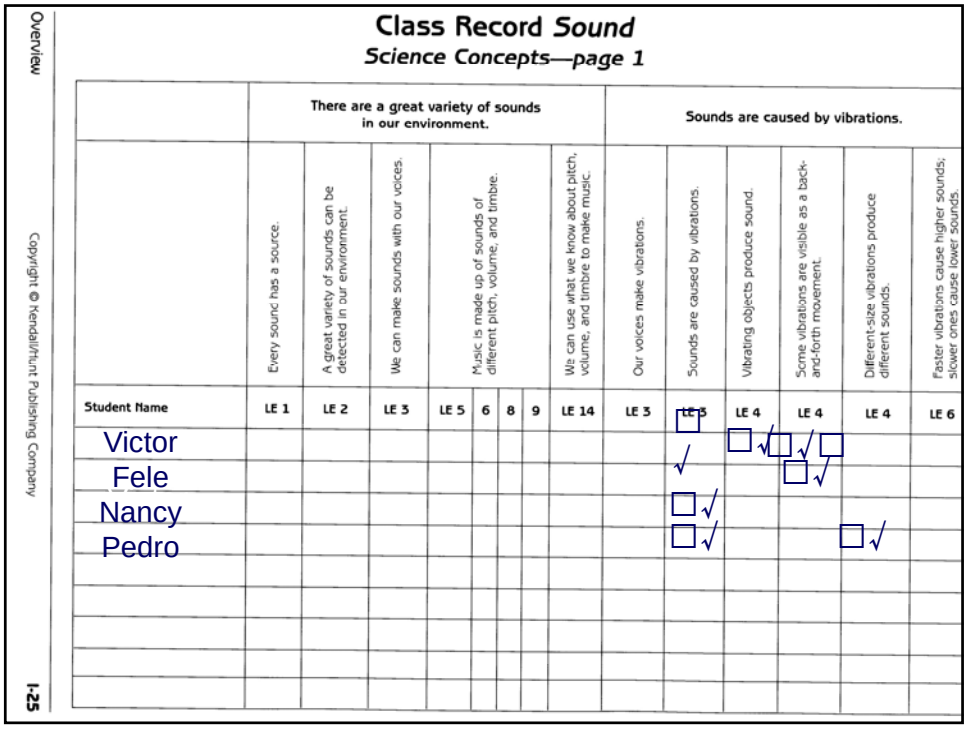
D. only vibrate if you can see the waves

Sound Exploration

Complete the assessment probe about Sound.

AAAS Benchmark

- Things that make sound vibrate. (K-2)
- Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. (6-8)



Overview

Class Record *Sound*

Science Concepts—page 1

	There are a great variety of sounds in our environment.							Sounds are caused by vibrations.					
	Every sound has a source.	A great variety of sounds can be detected in our environment.	We can make sounds with our voices.	Music is made up of sounds of different pitch, volume, and timbre.			We can use what we know about pitch, volume, and timbre to make music.	Our voices make vibrations.	Sounds are caused by vibrations.	Vibrating objects produce sound.	Some vibrations are visible as a back-and-forth movement.	Different-size vibrations produce different sounds.	Faster vibrations cause higher sounds; slower ones cause lower sounds.
Student Name	LE 1	LE 2	LE 3	LE 5	6	8	9	LE 14	LE 3	LE 3	LE 4	LE 4	LE 4	LE 6
Victor														
Fele														
Nancy														
Pedro														

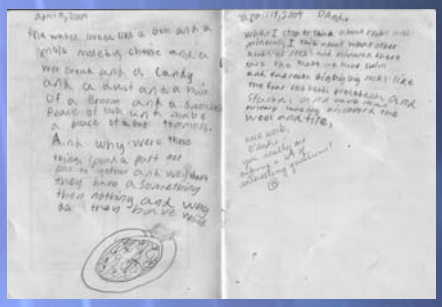
I-25

Writing GLEs K-6

- Student writes for a specific audience, including self, other children, parents and other adults. (K-3)
- Student writes for a variety of purposes and audiences. (3-6)

Research on Feedback

- "Black Box" articles
  - 1998, 2004
  - Black & William
- "Looking Into Students' Science Notebooks"
  - 2002
  - Ruiz-Primo, Li, & Shavelson



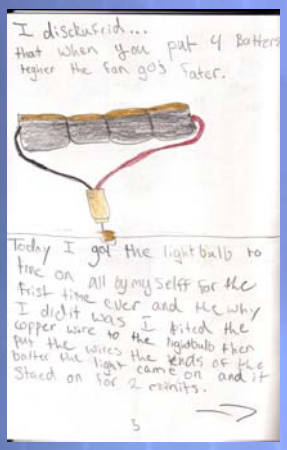
Kinds of feedback: Israel

- 264 low and high ability grade 6 students in 12 classes in 4 schools; analysis of 132 students at top and bottom of each class
- Same teaching, same aims, same teachers, same classwork
- Three kinds of feedback: scores, comments, scores+comments

Feedback	Gain	Attitude	
scores	none	top	+ve
		bottom	-ve
comments	30%	all	+ve

[Butler(1988) *Br. J. Educ. Psychol.*, **58** 1-14]

Feedback: A Star & A Wish



- Goals:
  - be specific, positive/ supportive, and clear
  - Keep in mind the specific skills and concepts on which you want students to focus for the entry.

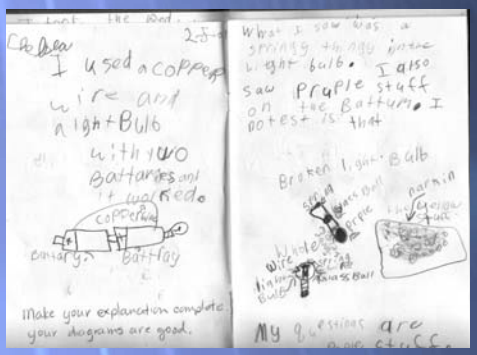
Consider…

- What will it take to close the gap between where the student is and where you want them to be?

Feedback: A Star & A Wish

- **A Star:**

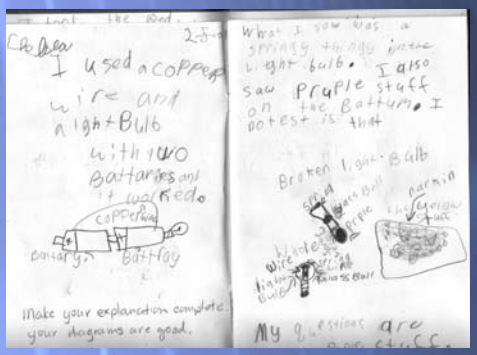
a constructive, complimentary statement about specific skills or knowledge expressed well in student's work



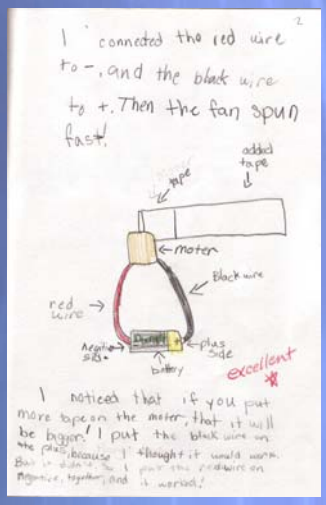
Feedback: A Star & A Wish

- **A Wish:**

constructive or challenging statement about skills or knowledge that could be improved with effort, practice, and/or attention



A Star & A Wish: Example



- Your diagram is very detailed and easy to understand with the colors and labels.
- It would be interesting to know more about what you were thinking when you put additional tape on the motor.

Student Self-Assessment

- Review your notebook entries
- Use the flags to mark your best examples in each category

Practice: A Star & A Wish

- Find a partner
- Trade notebooks with that person
- Using a sticky note, write a star and a wish for one page in the notebook you are reviewing.

Thinking Point

- What kind of feedback will you give your students to help close the gap between where they are and where you want them to be?

Discourse/Integration

As students talk about their experiences and the data they have collected and as they debate their ideas, they clarify their thoughts, generate conclusions, and develop new theories.

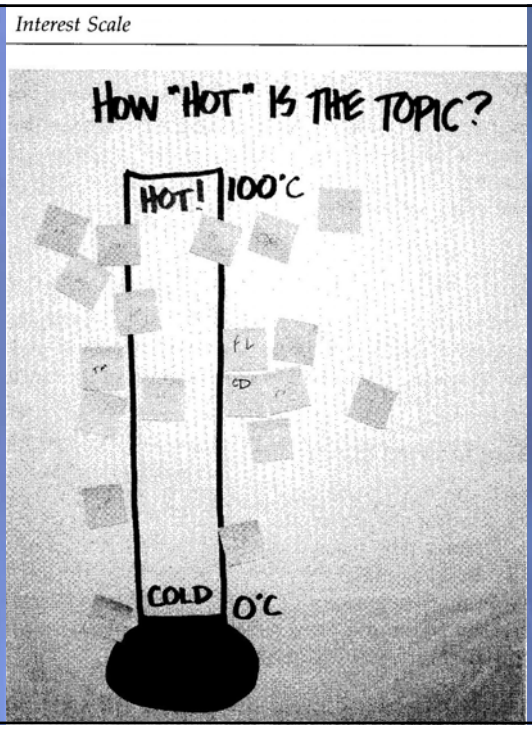
Looking Inside the Classroom

- 385 Math Science Classrooms, nationwide
- K - 12
- 15% of teachers take time at end of lesson to help students pull ideas together

Annotated Student Drawings

- MTV

- Making Thinking Visible



Chain Notes

- Find a partner
- Use 1 piece of paper
- Label the paper "Sound"
- Take turns listing what you know about sound

Chain Notes

- Best after lots of time on a concept
- Students move beyond recall since they must first read and synthesize what others have written
- Provides opportunities for students to think at various levels
- Analyze lists to assess what students are thinking

Cartoon Assessments

Which child's idea do you agree with? _____

Explain why.

_____

I used to think _____,
but now I know _____ .

Popsicle Stick Questioning

Recognizing Exceptions

- Is it always true that _____ ?
- Do you agree that every _____ ?
- Does _____ always result in _____ ?
- Does every _____ have a _____ ?
- Do all things _____ ?
- Could a _____ ever _____ ?
- What other examples can you think of?

Synectics

- Find two partners
- Draw a quadrant on the next blank page in your notebook.
- How is formative assessment like…

attending a conference	la fundidora
children on a playground	magnificant Monterrey

Strategy Review

- Take Off, Touch Down
- Assessment Probes
- Fist to Five
- Coding Pages
- MTV (annotated student drawings)
- Multiple Choice cards
- Student Self-Assessment
- Star and A Wish
- Student Checklist
- Observations
- Listening

3 - 2 - 1

- Three key ideas I want to remember about formative assessment
- Two ideas I still want to know more about
- One idea I am going to put into practice right away

Muchas Gracias