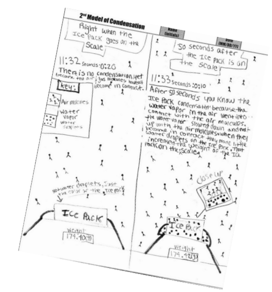


Supporting Scientific Practices in Elementary and Middle School Classrooms – What a LP Perspective Can Bring to Assessment and Instruction

Christina Schwarz
Michigan State University
Collaborators: PI: Brian Reiser, NWU; Lisa Kenyon, Wright State; Leema Berland, University of Wisconsin, Madison; Mark Wilson and Karen Draney, University of California at Berkeley

DRK-12: August 5, 2014

This research was funded by the National Science Foundation, grant DRL 1020316
Any opinions, findings, and conclusions or recommendations expressed here are those of the authors.

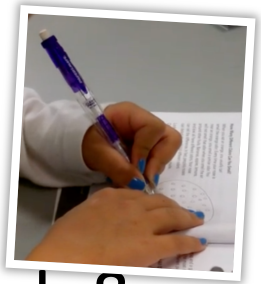
DRL 1020316

Project Goals

To investigate how learners develop proficiency in the different aspects of scientific practices involved in **argumentation**, **explanation**, **and modeling**

- How can we make science practices meaningful for learners in classrooms?
- How do students develop increasing sophistication in their understanding about and performance of scientific practices?

Why?

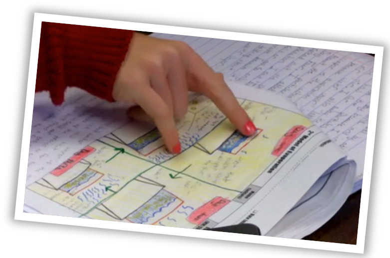


- Scientific practices taking an increasingly important role in classrooms (e.g., Framework & NGSS)
- Teachers and students can learn to engage in procedural aspects of practices (e.g., CER for argumentation; creating art for modeling)
- It is challenging to make practices meaningful. Schools often automate and proceduralize, so teachers and children end up "doing school" rather than using practices to make sense of phenomena in the world.

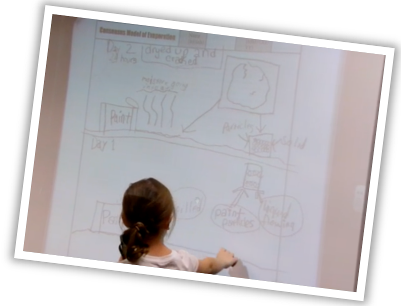
Research Goals

If we want to support learners at engaging in scientific practices in a way that is: meaningful for learners in a knowledge-building community and consistent with norms in science, we need to:

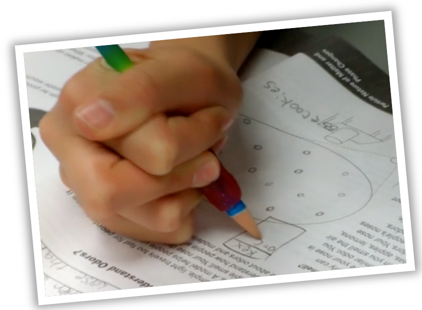
- Capture ways of 'seeing' whether and how students' epistemic practices develop/shift or improve over time
- Determine how these shifts might be occurring
- Help teachers support their students in developing rich epistemic practices



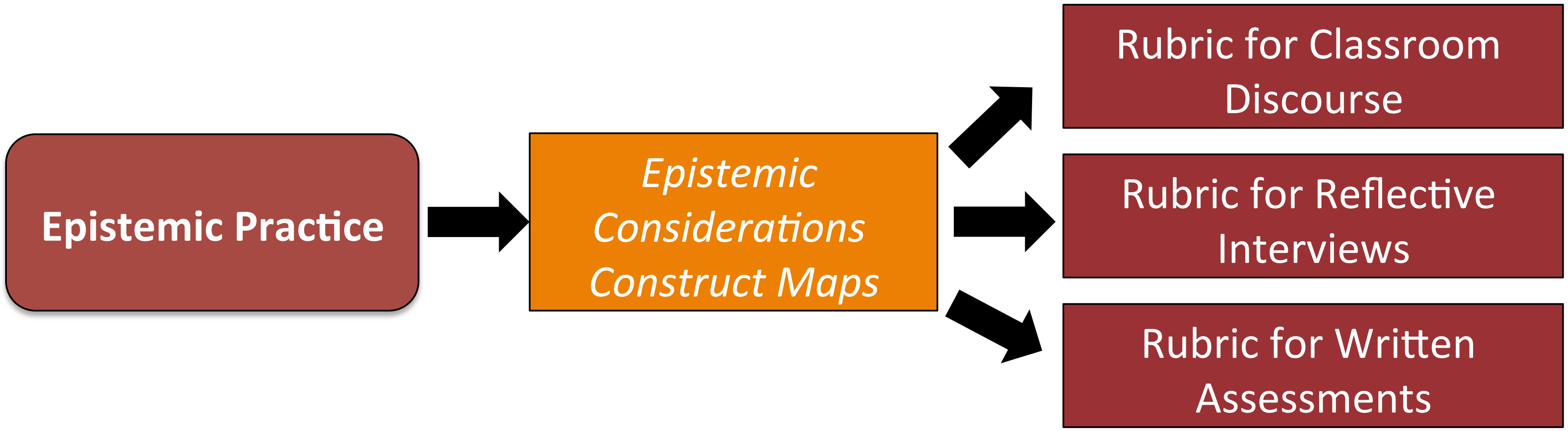
Epistemic Practice



- *Epistemic practice*: Considering aspects of the nature of knowledge/knowing when engaged in scientific knowledge building and revising.
- *Epistemic considerations*: Issues that guide students' knowledge-building decisions, evident in their products, discourse, and rationales.

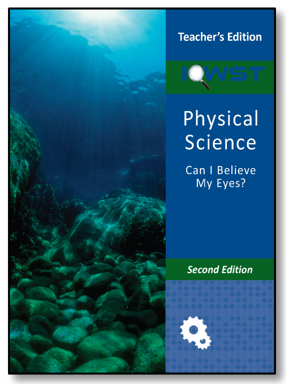


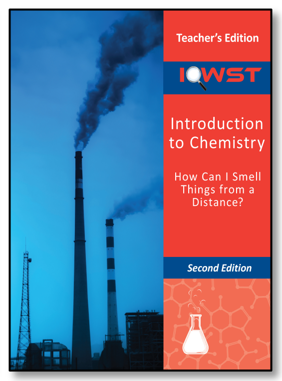
Theory → Construct Maps → Rubrics

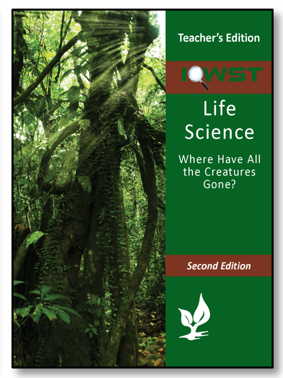


Studies

- Comparative and Longitudinal Studies Across Grades, Science Strands, and Scientific Practices
  - 5^{th} through 6^{th} grade (MI & OH)
  - 6^{th} through 8^{th} grade (OH & IL)
- Curriculum Materials Across Content
  - MoDeLS evaporation/condensation (5^{th})
  - IQWST units (6^{th} – 8^{th})
    - Physics
    - Chemistry
    - Biology
    - Earth Science







Sample Curricular Context

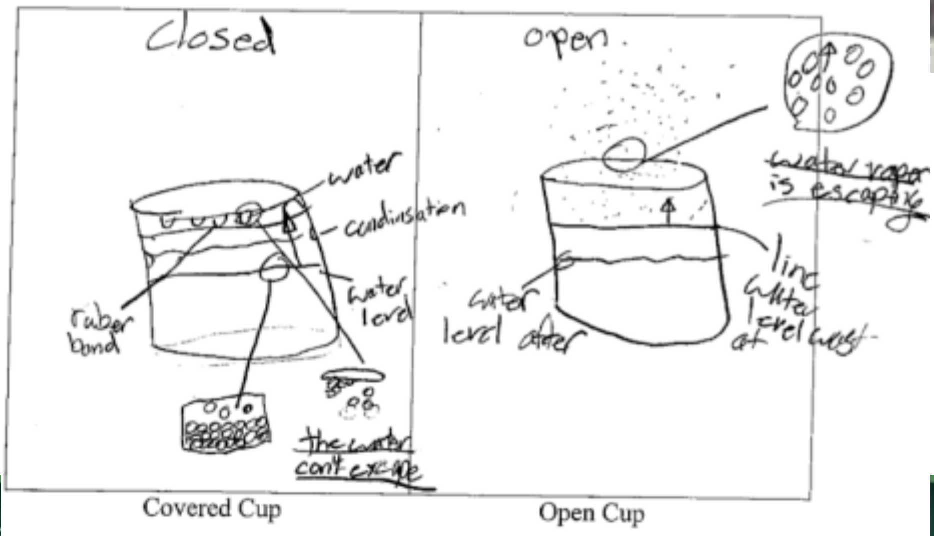
- MoDeLS 5th grade evaporation/condensation unit. Students constructed, evaluated and revised diagrammatic models of phenomena with respect to empirical data and science ideas to address question:

  How/why does water appear or disappear on/ from surfaces?

- IQWST 6th grade chemistry unit

  How can I smell an object from across the room?

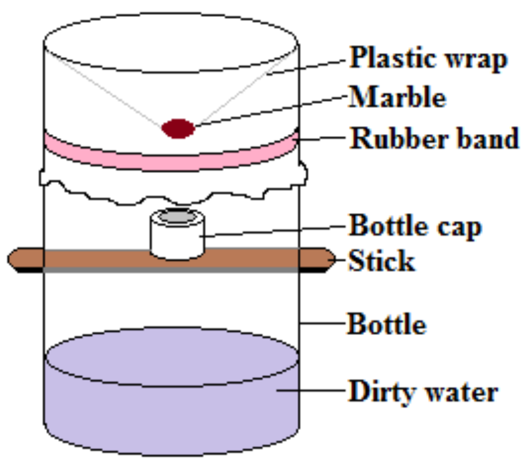
5th Grade Evap/Condensation



(1) Central Question

Anchoring phenomena and central question:

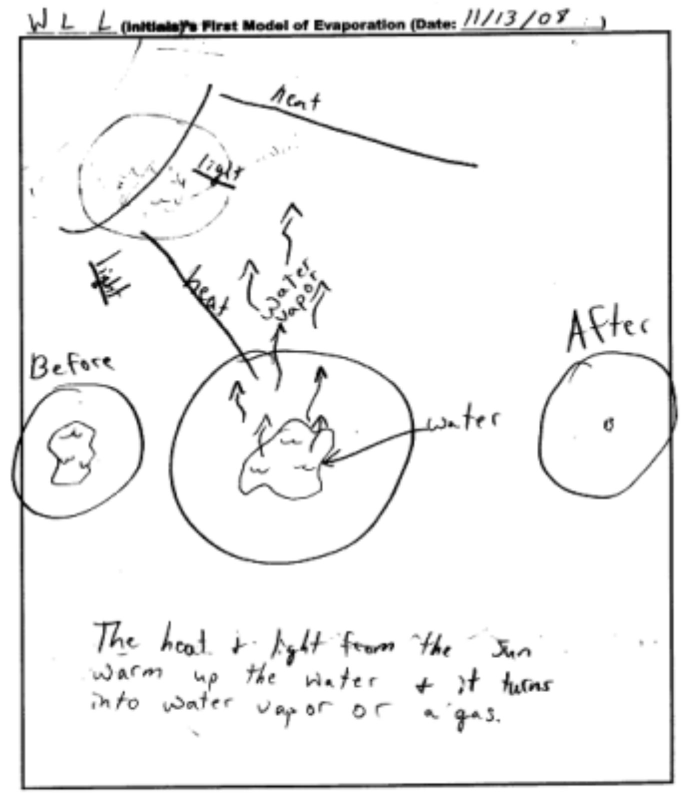
Would you drink the liquid in the bottle cap from a solar still?



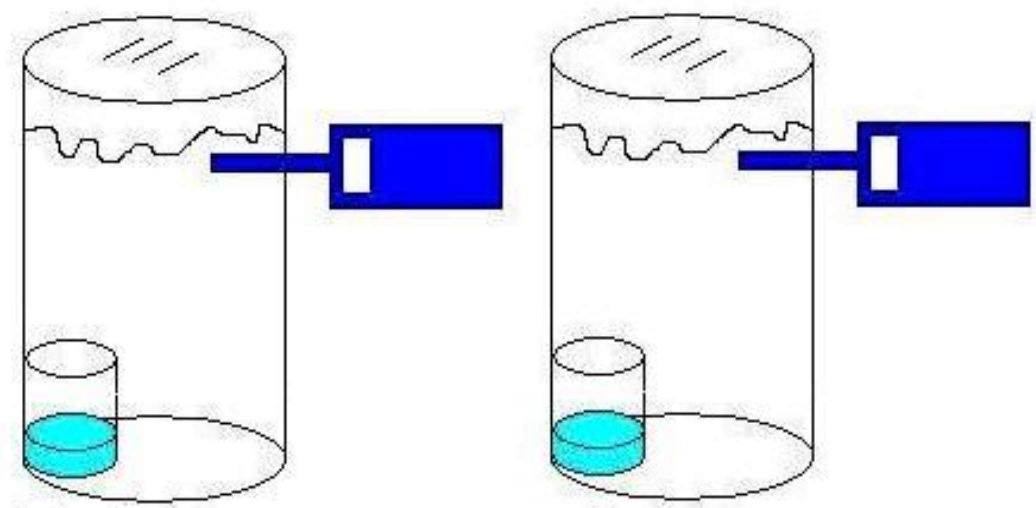
A solar still

(2) Initial Model

Develop an initial model of evaporation – what happens to the water? (second half of unit on condensation)

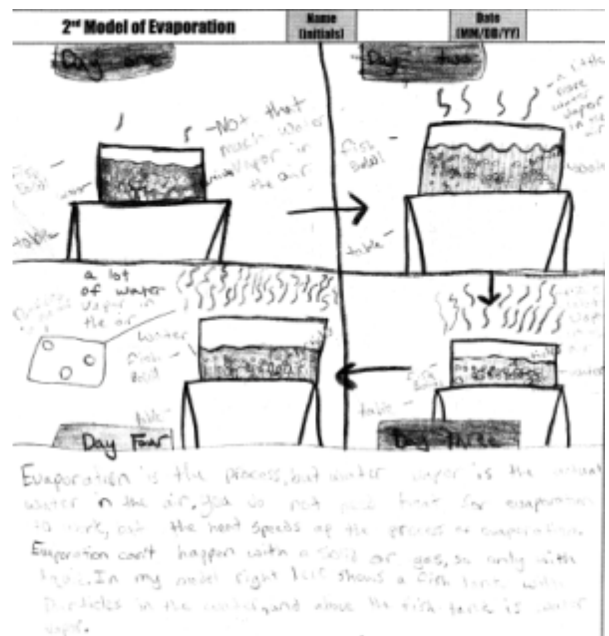


(3) Empirical Investigations

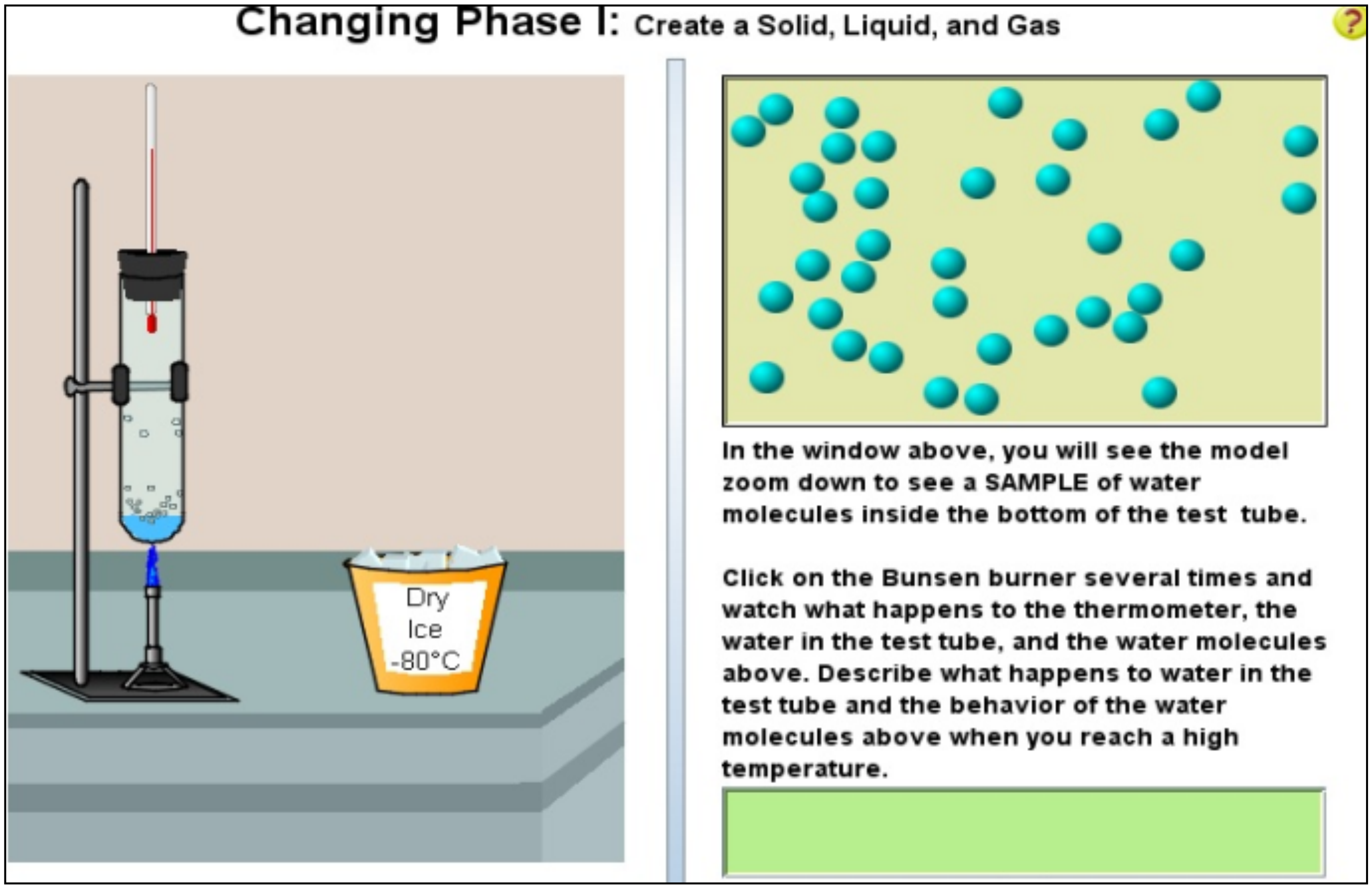


Using humidity detectors to measure water vapor levels from evaporation and condensation

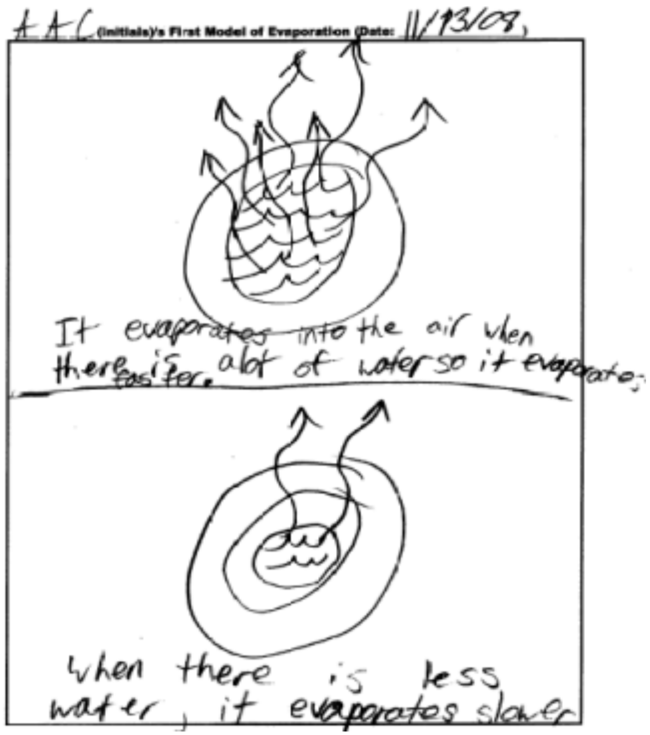
(4) Evaluate and Revise Model



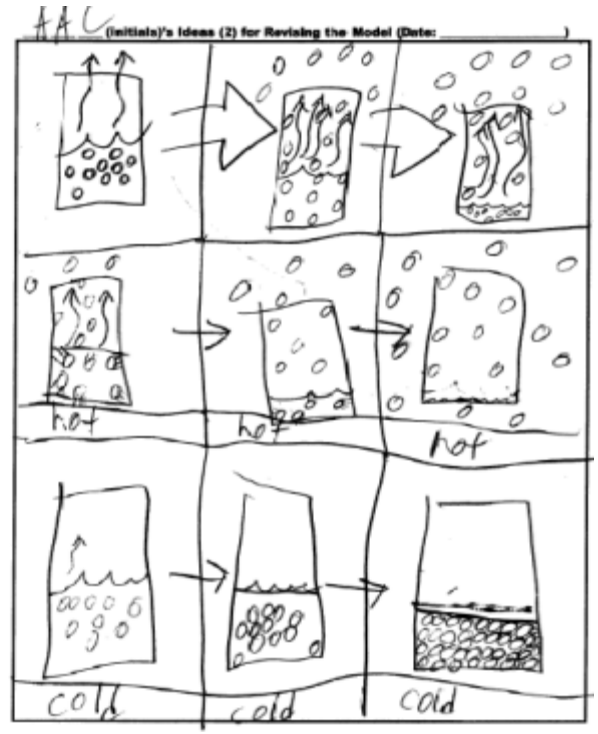
(5) Introduce scientific ideas and simulations



(6) Evaluate and Revise Models

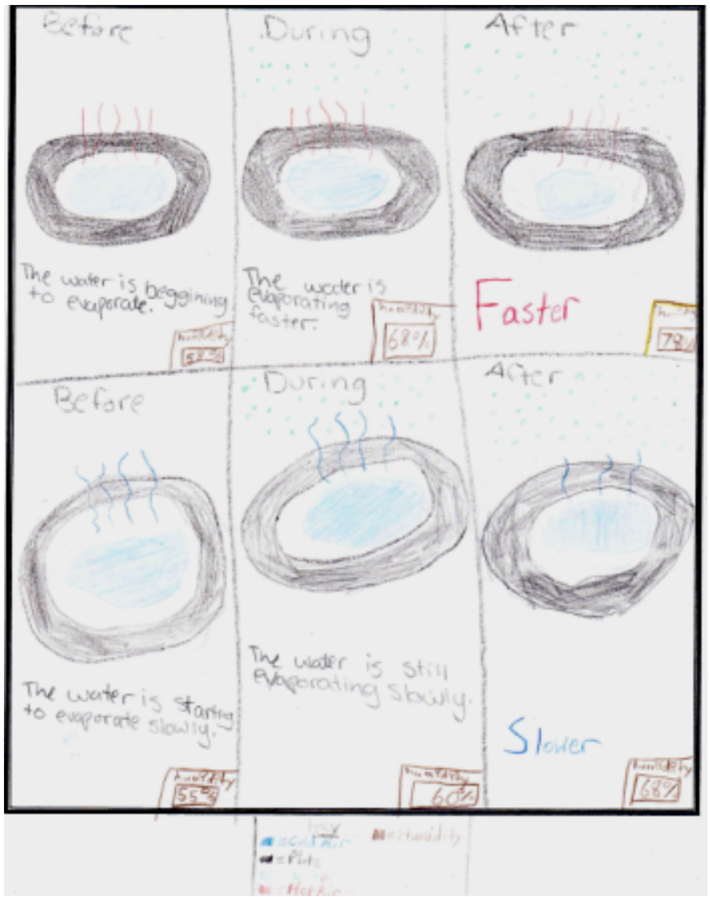


Evaporation model before simulation

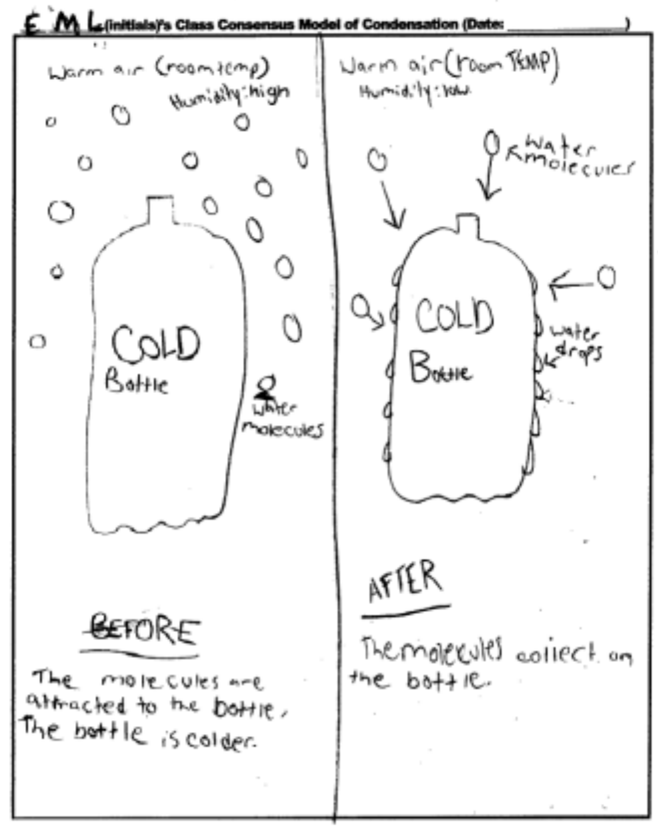


Evaporation model after simulation

(8) Construct a consensus model

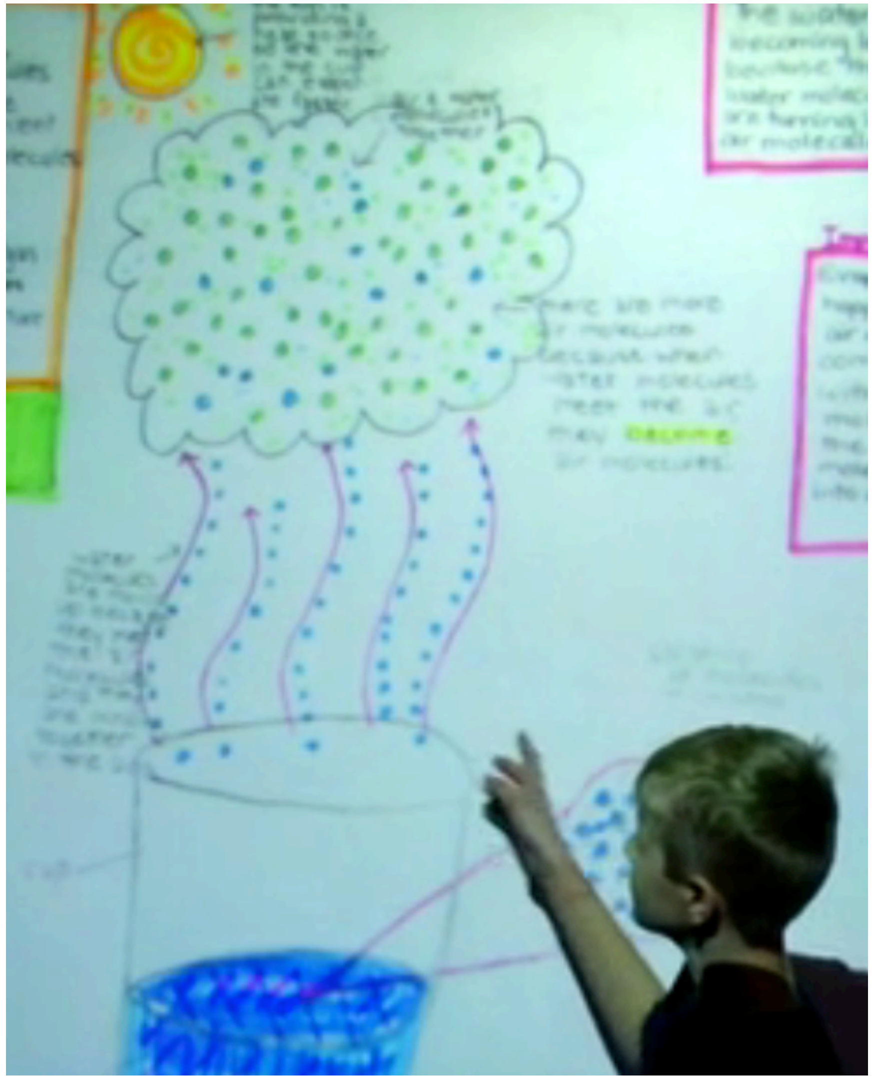


Small group evaporation consensus model

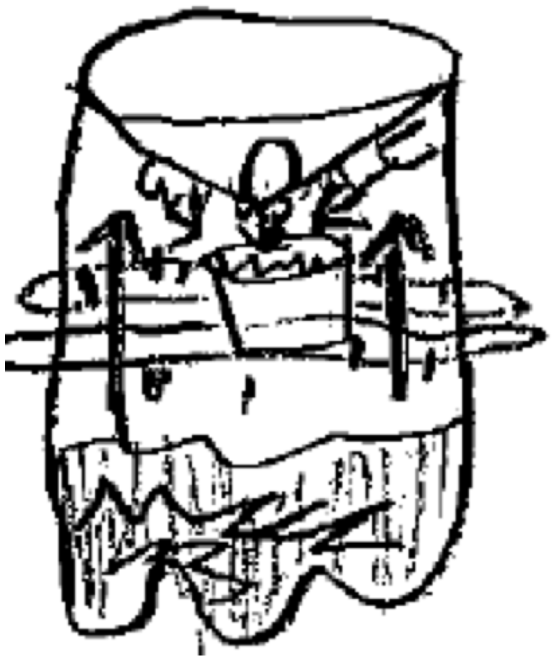


Example of whole class condensation consensus model

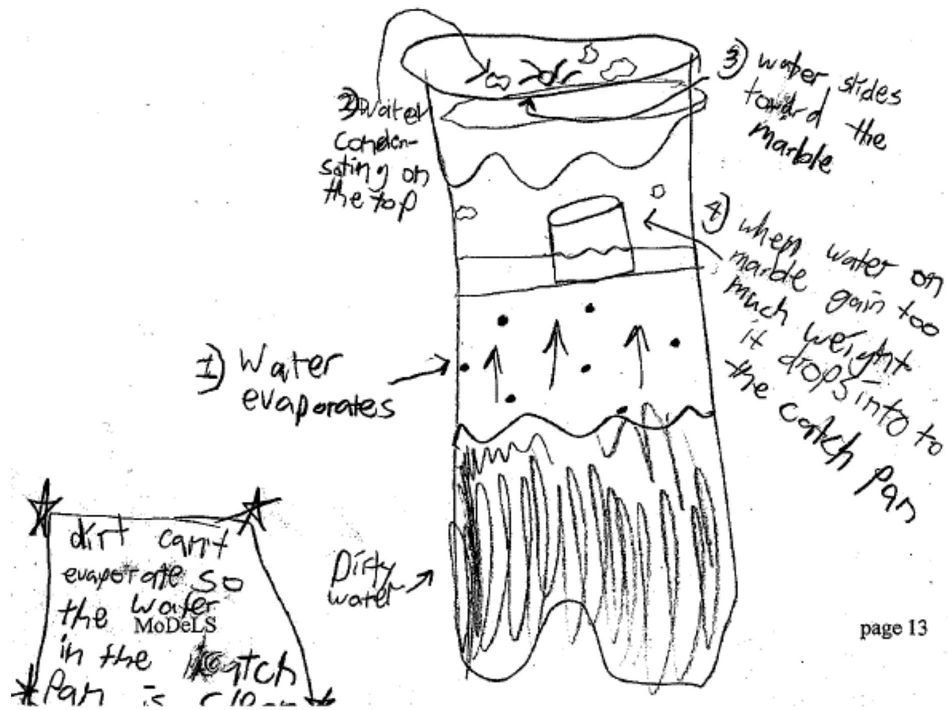
(7) Peer comparison and evaluation



(9) Use model to predict and explain



Pre-test



Post-test

Research Question

Do students' epistemic practices develop/shift or improve over time? If so, how?

Using our construct map rubrics to determine how this happens in:

- Classroom Discourse
- Interviews
- Written Assessment Items

Construct Maps: 4 Epistemic Considerations

- What kind of answer should our knowledge products provide? **nature**
- How do we justify our knowledge products? **justification**
- Who will use our knowledge products and how? **audience**
- How should our knowledge products connect to other scientific phenomena and ideas? **generality**

Classroom Discourse Example: Group Work Developing a Model - 5th grade

Who thinks we should do the warm and cold pop cans?

I think we should do a **solid object**, to show first that the liquid…**to prove that** the liquid comes from the air. audience

But with the pop can, you **can tell the liquid isn't pop**.

If you're going to talk about pop, then it's just going to say "pop." We're just going to **say "liquid," so it can be flexible**. generality

I know, but we're figuring out [what examples to use] …, **so we know that it's not coming from the can**, it's coming from the air. audience

Epistemic Considerations

- **What kind of answer should our knowledge products provide?**

  nature

  Details; factors or sequences; step by step causal mechanisms (Braaten & Windschitl, 2011; Russ, Scherr, Hammer, & Mikeska, 2008)

- How do we justify our knowledge products?
- Who will use our knowledge products and how?
- How should our knowledge products connect to other scientific phenomena and ideas?

Rubric for Nature EC

nature

Level	What kind of answer should my knowledge product provide?
3	a partial or full mechanism-based explanatory process that addresses **"why it is happening"**
2	a partial or full descriptive account (or sequence) that addresses **"how it is happening"** without a mechanism-based explanatory process
1	details that only focus on visible aspects of **"what is there"** in the phenomenon

Rubric for Nature EC

nature

Level	What kind of answer should my knowledge product provide?
3	a partial or full mechanism-based explanatory process that add
2	a partial or full des that addresses **“h** mechanism-b
1	details that only focus on visible aspects of **“what is there”** in the phenomenon

Water appears on the outside of a cold can because water is condensing and when more and more water is collected, it drips down.

Rubric for Nature EC

nature

Level	What kind of answer should my knowledge product provide?
3	a partial or full process that a
2	a partial or full descriptive account (or sequence) that addresses **"how it is happening"** without a mechanism-based explanatory process
1	details that only focus on visible aspects of **"what is there"** in the phenomenon

When it is hot, water will evaporate and go into the air.

Rubric for N

When water particles in the air touch something cold, they will start to slow down, clump together, and turn into a liquid.

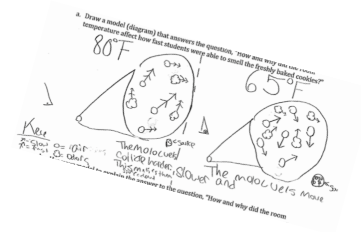
Level	What kind o knowledge
3	a partial or full mechanism-based explanatory process that addresses **"why it is happening"**
2	a partial or full descriptive account (or sequence) that addresses **"how it is happening"** without a mechanism-based explanatory process
1	details that only focus on visible aspects of **"what is there"** in the phenomenon

Interview Sample: Analysis of Nature EC

Nature

Mechanism Level 2 after Evaporation	Mechanism Level 3 after Condensation
I: if I'm a person who does not understand evaporation, do you think you can use this model to explain evaporation to me? RS: Evaporation is the process but water vapor is the actual water in the air. … My model right here shows **a fish tank with particles in the water, and above the fish tank is water vapor.** I have a fish tank at home so I actually did this experiment. The first day we got it, the water stayed at the same height. It kind of felt a little humid above it. Then day two, there was a little less water in the tank and I thought that was because it evaporated. …	I: What does your [condensation] model show? RS: …In this picture right here, showing that the Coke can has water drops on it … this is how condensation works. **The water vapor is gas so if the water vapor touches coldness, then it will turn into liquid. This process is called condensation. This happens because the molecules slow down and turn into liquid on the Coke can.**

Sample 6th grade Chemistry Written Assessment Item



Ms Watson made freshly baked cookies for class for two days. On the first day, her room is really hot (80F) and the students smell cookies as they enter the room. On the second day, the room is cooler (65F), and the students do not smell cookies until they sit in their seat. The students smelled the cookies faster when the room was warmer.

a. Draw a model (diagram) that answers the question, "How and why did the room temperature affect how fast students were able to smell the freshly baked cookies?"

b. Use your model to explain the answer to the question, "How and why did the room temperature affect how fast students were able to smell the freshly baked cookies?"

SCIENTIFIC PRACTICES

Mechanism Scoring Chart for Written Items

Descriptive Account/Explanatory Process Continuum

Multiple Levels	Generalization	What's involved?	How are they involved?	How complete is my causal story?	Alternative Theory
VISIBLE/NON VISIBLE; INDIVIDUAL/ AGGREGATE Response includes more than one "level" in modeling/ explaining the phenomenon. With this code, we would like to see whether students include a level that is not obvious (or not observable) from the question stem.	SCIENTIFIC PRINCIPLES OR GENERAL RULE Empirical regularities or patterns that can be seen in more than one instance. It is the general scientific idea or "truth" or "law" that describes how the world works. We are interested in whether students use generalized knowledge in explaining or modeling a specific phenomenon in question.	IDENTIFYING OR NAMING FACTORS A student names the relevant term or agent that explains the phenomenon. There may be multiple relevant factors, which are specified as a) b) c), etc, in the specific item guide. Generally the last factor will be "other," for factors that students name that are not the correct response and/or for instances in which students do reasoning about an ambiguous factor	SPECIFIC VERBS EXPLAINING WHAT THE FACTORS DO Given the terms or agents that a student names, this component captures whether or not they do any reasoning about how or why that factor explains the phenomenon. If a student names factor 1a, their reasoning is coded as 2a regardless of whether or not it is the correct reasoning about 1a.	QUALITY OF REASONING This captures how complete is the causal story in the response. It aligns to some degree with the presence or absence of 2a and 2b but also requires some coder discernment, especially in responses coded as 2c	"OUT IN LEFT FIELD" RESPONSES The Alternative Theory code captures instances in which students are not providing the correct mechanistic explanation, broadly speaking. If students are in the ball-park range of what we would expect, but they have a few details incorrect, their response should NOT be coded as an Alternative Theory

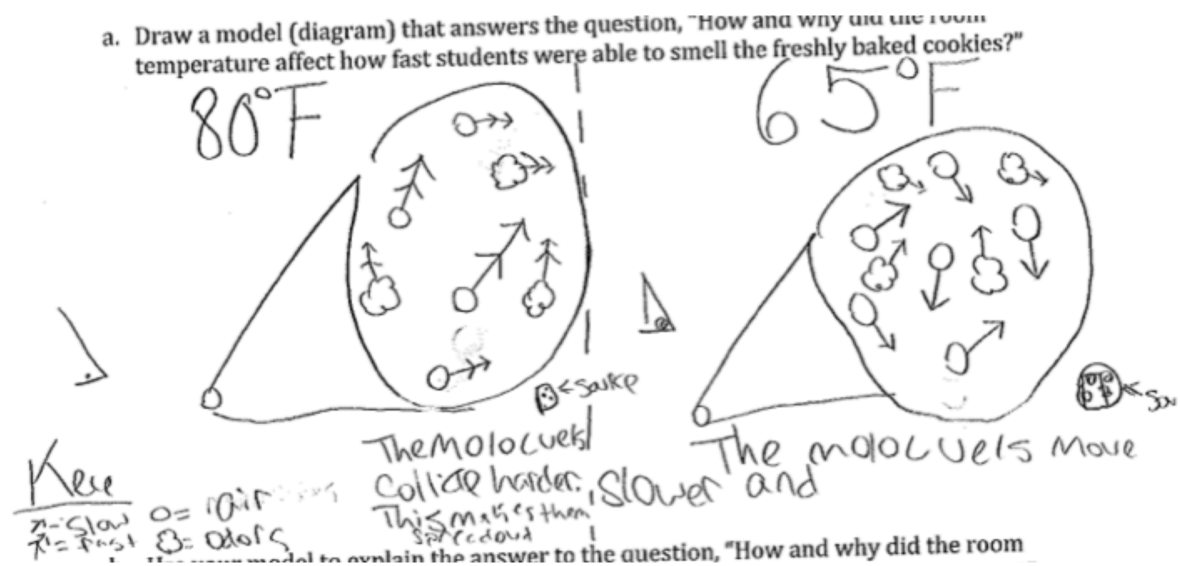
Examples from Written Assessment

Descriptive Account/Explanatory Process Continuum

Multiple Levels	Generalization	What's involved?	How are they involved?	How complete is my causal story?	Alternative Theory
Physics/ Chem: nonvisible theoretical entities (particles, molecules) vs. macro-level phenomenon (odor traveling) **Bio:** individual vs. aggregate/ population	"Hot air rises." "The hotter it gets, the more molecules move and travel."	**1a**: air, air particles, or some kind of particles **1b**: temperature (given; not coded) **1c**: Other factor (e.g. wind, snowflakes, density)	**2a**: *how* particles are working (carrying, pushing, bouncing, colliding, etc) **2b**: temperature *comparison* matters **2c**: *how* does other factor work (hitting, curving, carrying, etc.)	**0** – no reasoning (no 2-level code) **1** – vague, nonsensical; not drawing on evidence provided; reasoning must be *inferred* from response **2** – partial causal story; reasoning about one factor but not the other (e.g. 2a but not 2b) **3** – complete causal story (2a + 2b; OR 2b + 2c, etc)	"When it is hotter it lets smell go through easier while when it's cold it absorbs more of it."

Sample Written Assessment Response

"The molocules (sic) **move faster when it is warmer** because the molocules (sic) move faster **and collide harder. The harder they collide the more they spread out letting them smell them faster**."



Teacher's Use of EC's

Mrs. M: What we think about when we are reviewing models? Do you just go up to somebody's model and be like "Hey man. This's a good model. This looks good. You have molecule, I see water, all done, thank you. … **What [do we need to think about when] you come to your science class and when you are looking at a model?** … [Students mention EC's]

How would you revise your model **based on the investigation**? … How many of **you used the evidence**? How many of you **provide the mechanism,** the how and why piece? The audience? **What kind of things do you ask when you think of audience**?

Evaluating Models Using EC's (stars and wishes)

Mrs. M: So that would be an evidence piece. That's a great suggestion! J, do another one.

J: I wish…er…compliment first. I wished (inaudible)…

Mrs. M: So **you liked that he showed molecules**. And **you wish he could show which one is air and which one is water**. Interesting. Why do you wish that?

J: Especially the uncovered one. **It showed it's evaporating, but we don't know which water molecules in the cup have already evaporated and which haven't**.

Mrs. M: What do you think, S?

S: (inaudible)

J: Yes, because in your mind, **you S know what this molecule is doing and what that molecule is doing, but whoever's looking at it might not know that**.

Post-Condensation Interview: How Meaningful are ECs?

I: Do you believe all those criteria [epistemic considerations]? Do you think they are all important?

J: Yeah, they're definitely all important … for mechanism - what's the point of a model if it doesn't explain how it's happening? That's the whole point of it. And evidence [information] sort of shows people that it is possible. … For evaporation [the teacher] said that [the water particles] are sort of attracted to the air molecules, but she didn't say exactly how that worked or anything."

I: Did you think you have evidence[information] in your model?

J: As much as I know. [My model] says that [the water particles] slow down but it doesn't say why they slow down. [Our teacher] never told us why they slow down, besides that they're getting near something cold . …it's kind of hard to come by because at this grade they give you some evidence [information] but they don't tell you the whole thing.

Discussion: Assessment

How can a LP perspective help us make progress around assessment and instruction?

- If our goal is to help make scientific practices more meaningful and to determine whether that occurs and students' practices develop over time, we can:
  - Operationalize the epistemic considerations over multiple kinds of data (classroom, interviews, and written assessments)
  - Follow their shifts/development over time in multiple science contexts
  - Determine how the outcomes from the different data triangulate with one another
- We need to analyze *all* kinds of data to determine how and why shifts and developments are occurring (e.g., Schwarz et al. ICLS case studies)

Discussion & On-Going Work

- Current research about the role of teachers in developing students' epistemic practices
  - Some preliminary evidence that the epistemic consideration rubrics may be helpful, but it might lead to procedural evaluation by some teachers. Need to explore further.
- On-Going Work: Iterative refinement between construct maps (epistemic considerations), data, assessments, and analysis of teaching to continue understanding how to better support epistemic practices.

Thank You!

- Participating students and teachers

- Scientific Practices
- National Science Foundation