UNIVERSITY *of* WASHINGTON

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Ambitious Teaching as Rigorous *and* Responsive Science Discourse

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http://tools4teachingscience.org

NSF
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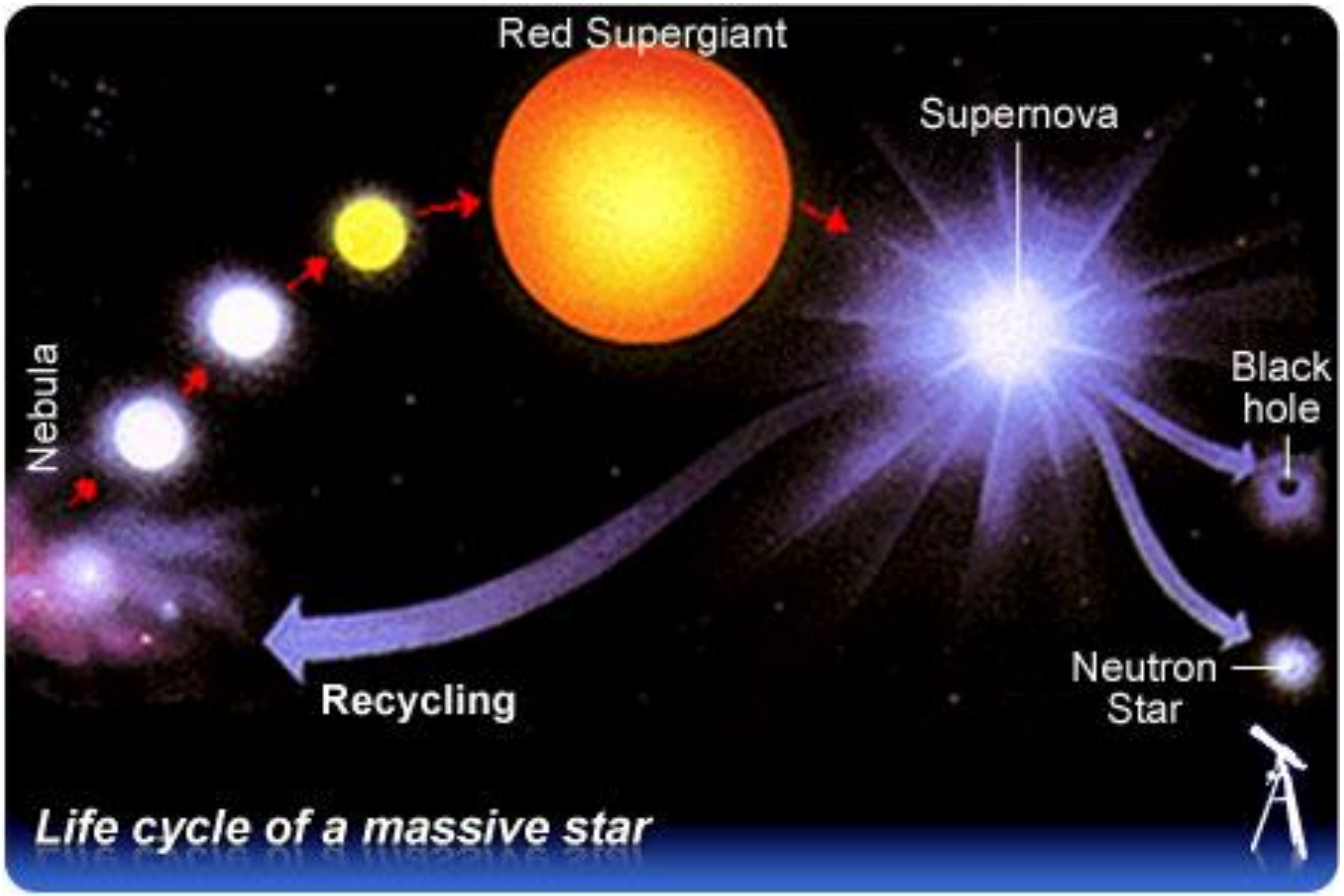

Red Supergiant
Supernova
Nebula
Black hole
Neutron Star
Recycling
Life cycle of a massive star

Research Context

- 2 year study designed to investigate how teachers appropriate high-leverage science teaching practices in middle and high schools in large urban districts
- Participants
  - Novice teachers, cooperating teachers, district coaches

A Challenge:
The Cultural Landscape

Patterns in classrooms

- Lack of student engagement
- Content presented as facts, definitions, algorithms; pressing for explanations is rare
- Few connections between activity and science ideas
- Student ideas not used as resources, no challenging of ideas
- Questioning and discourse the weakest aspect of classroom practice

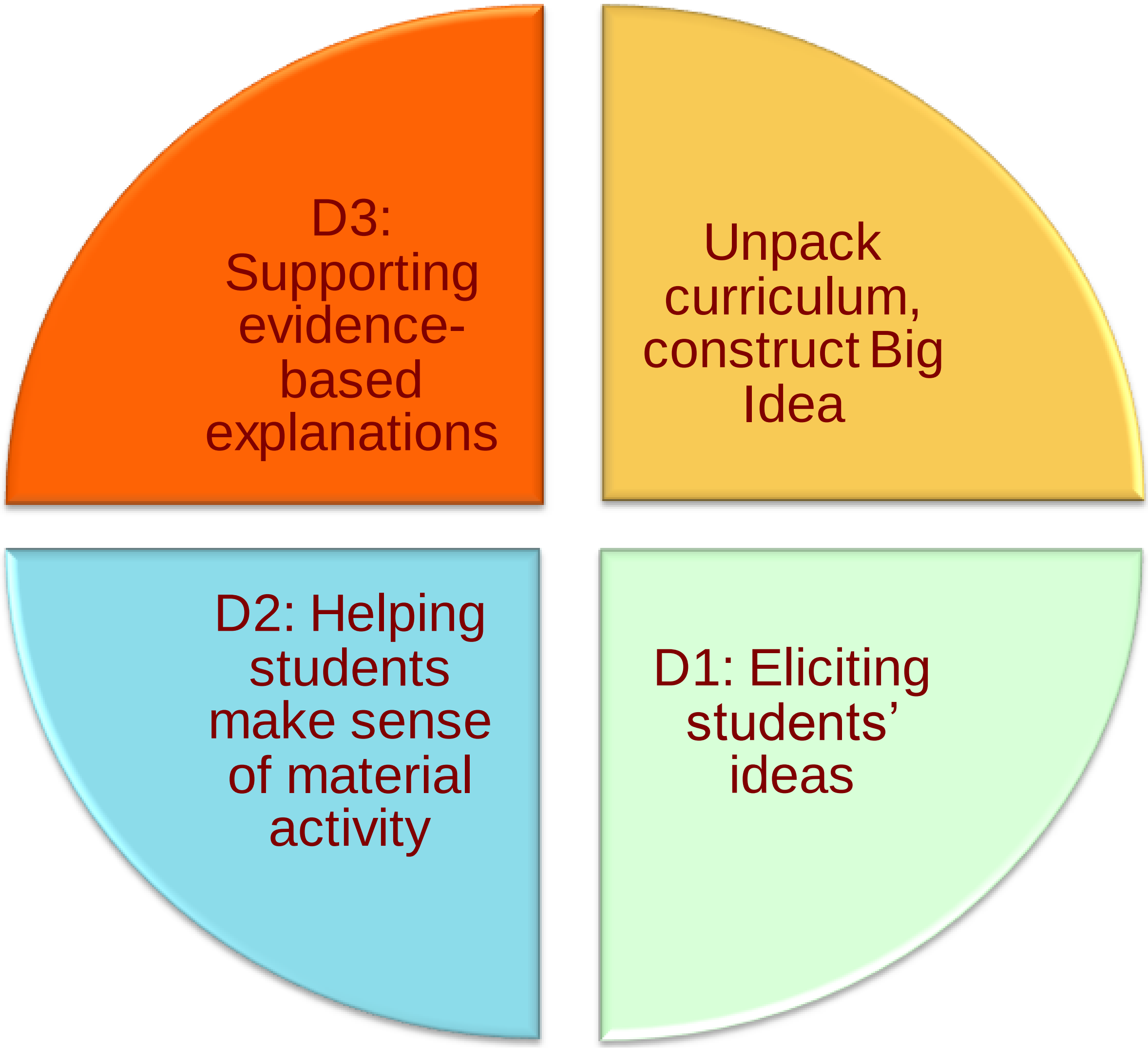
What students are capable of

- Reasoning about and with abstractions (Magnussun & Palincsar, 2005)
- Model-based reasoning (Lehrer & Schauble, 2005)
- Defending, adapting, theories based on evidence (Hennessey et al., 2002)
- Designing experiments that include sophisticated controls for external variables (Metz, 2004)

Monitoring own progress towards deep understanding (Brown & Campione, 1996)

Corcoran & Gerry, 2011; Kane & Staiger, 2012; Pasley, 2002; Roth et al., 2006; Weiss et al., 2003

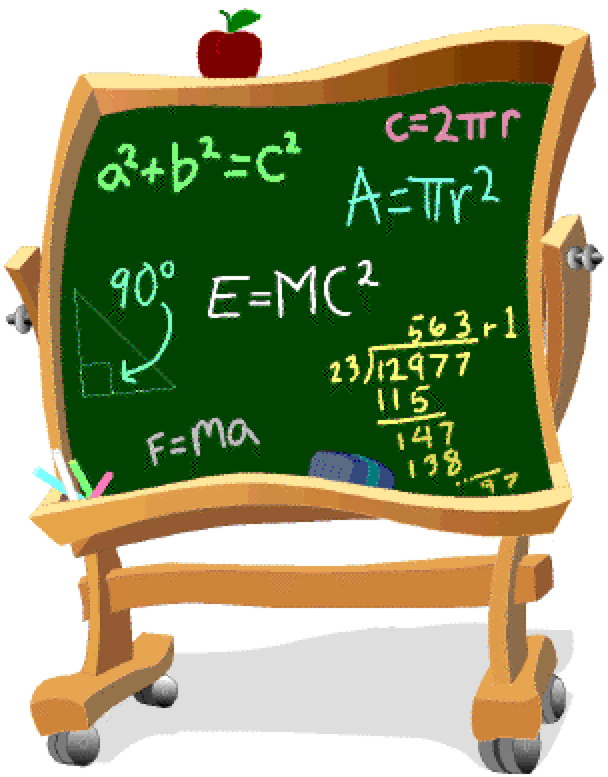
Four core practices organized around adaptation of *Model-Based Inquiry*



All four practices are linked in literature to student participation in science and to learning

Not coincidentally, these are practices important to the Next Gen standards

RIGOR & RESPONSIVENESS



Responsive by whom?, toward what? and for what purpose?

Level 1- Teacher is responding to students' utterances as "possible answers" to support individuals in reproducing canonical science ideas

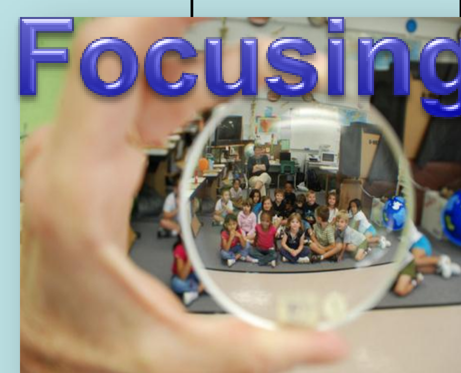
Level 2- Teacher responding to multiple students' partially correct ideas to construct science ideas and build community

Level 3-Teacher and students responding to interaction of ideas and how they are rooted in different discourse communities to make progress on ideas and build identities across communities

(Bereiter, 1994; Chi, 2008; Michaels, O'Connor & Resnick, 2007)

Rigorous and Responsive Discourse

N=201 lessons, 37 te		**Teacher and Student Responsiveness-** building on students' ideas, supporting participation structures, building on students' lived experiences		
		No	Low	High
Students' Rigor- constructing scientifically important big ideas and models, developing evidence-based scientific explanations, and describing epistemic features of models and explanations	No	26%	1%	0%
	Low	18%	27%	**8%**
	High	1%	7%	**12%**



3 types of Responsiveness

Students' scientific ideas	Formative assessment, conceptual change, teacher moves, accountable talk, productive disciplinary engagement (Coffey et al., 2011; Engle & Conant, 2002; Pierson, 2008)
Social dynamics	Argumentation, socio-scientific norms, complex instruction (Cohen,; Herrenkohl & Guerra, 1998; Neito,1999; Wenger, 1998)
Lived experiences & developing identities	Resource pedagogies, Funds of Knowledge (Calabrese-Barton, 2000; Gutiérrez, Baquedano-Lopez & Tejeda,1999; Ladson-Billings, 2001; Paris, 2012)

S1: Would ash be considered a physical change? Like an egg?

S2: So we did an example of melted cheese.

TC: So what did we just have in the back of the class?

S3: We thought also that it was physical changes even though it comes after melting and boiling.

S4: I don't agree with that because even though there was a color change CO_2 was emitted so the identity of the log would have had to have changed

TC: Does anyone have something to add to this? …

CT: so this is chemistry. Let's think about this at an atomic level…What makes up an egg?

S5: Elements

S6: Potassium

TC: Be specific

S7: Proteins, and when we cook proteins the proteins change

TC: What does it look like? What happens when it cooks? [TC draws on board and shows a tightly bound protein and an unwound protein.]

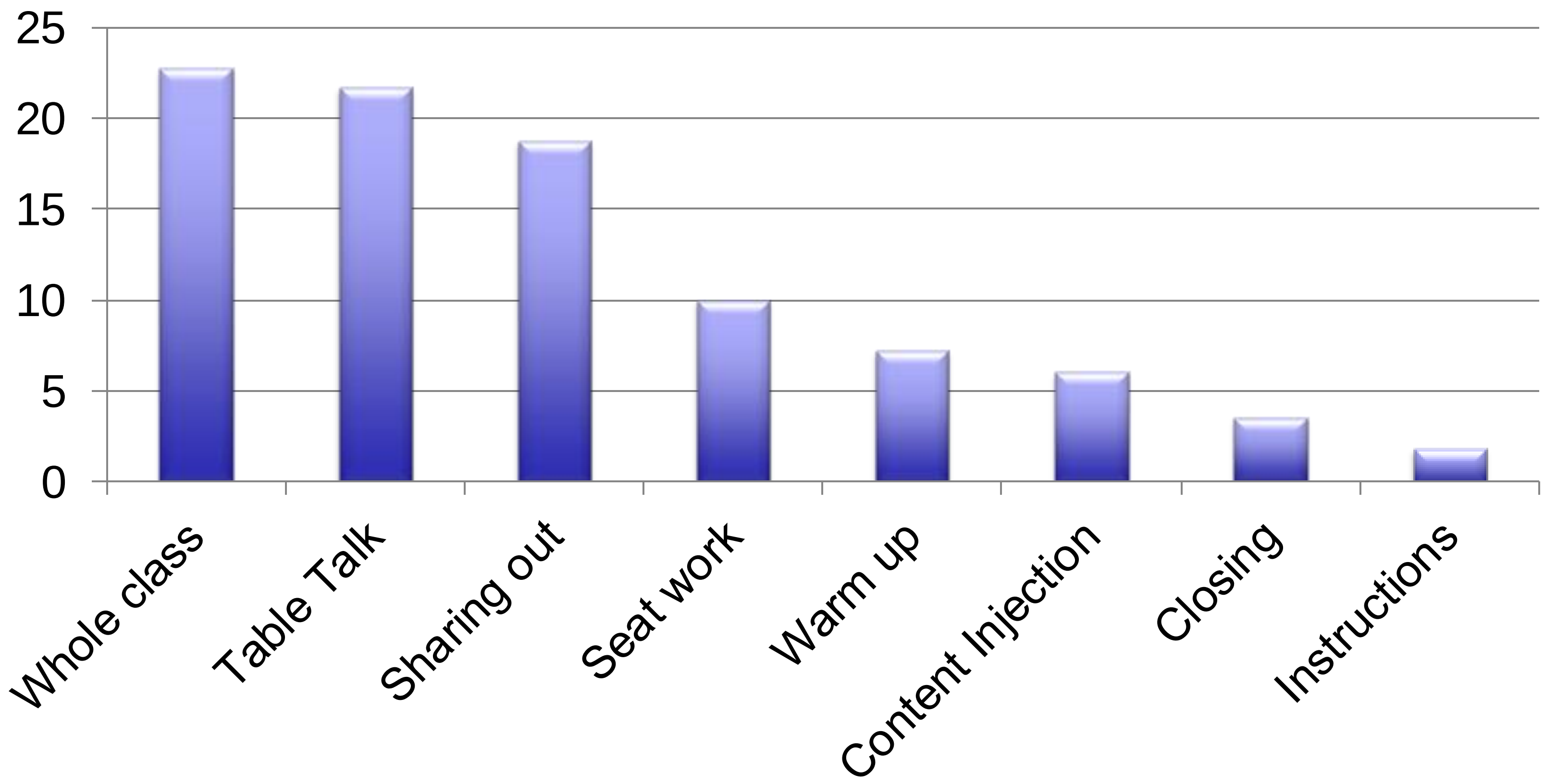
S7: So it is breaking and forming bonds

S8: It expanded because of heat. When it heated they [bonds] move apart rather than together.

Building on students' ideas, supporting participation structures, leveraging students' lived experiences supported the elevation of students' rigor.

Leveraging lived experiences was not a prerequisite for elevating rigor, in most cases teachers approximated relevance, as a "hook," and were not able to lift the level of rigor in the classrooms.

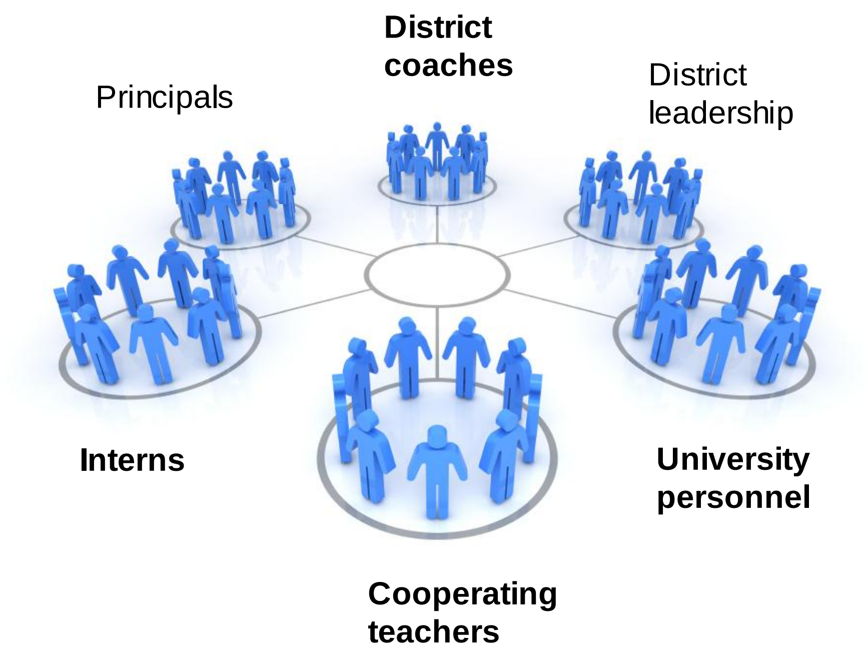
Percent of Lesson Episodes High Rigor/High Responsiveness



The use of multiple episodes, and specifically transitioning between whole group and small group episodes, raised the level of students' explanations when whole group conversations were used to reflect on the quality of the scientific explanations being generated.

Improving teaching as well as teachers

- System of learning opportunities, tools, and formative assessments
- Broader teacher education community can collectively refine these practices, tools, other resources



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Tools for Ambitious Science Teaching

Website: http://tools4teachingscience.org

In appreciation of funding from:

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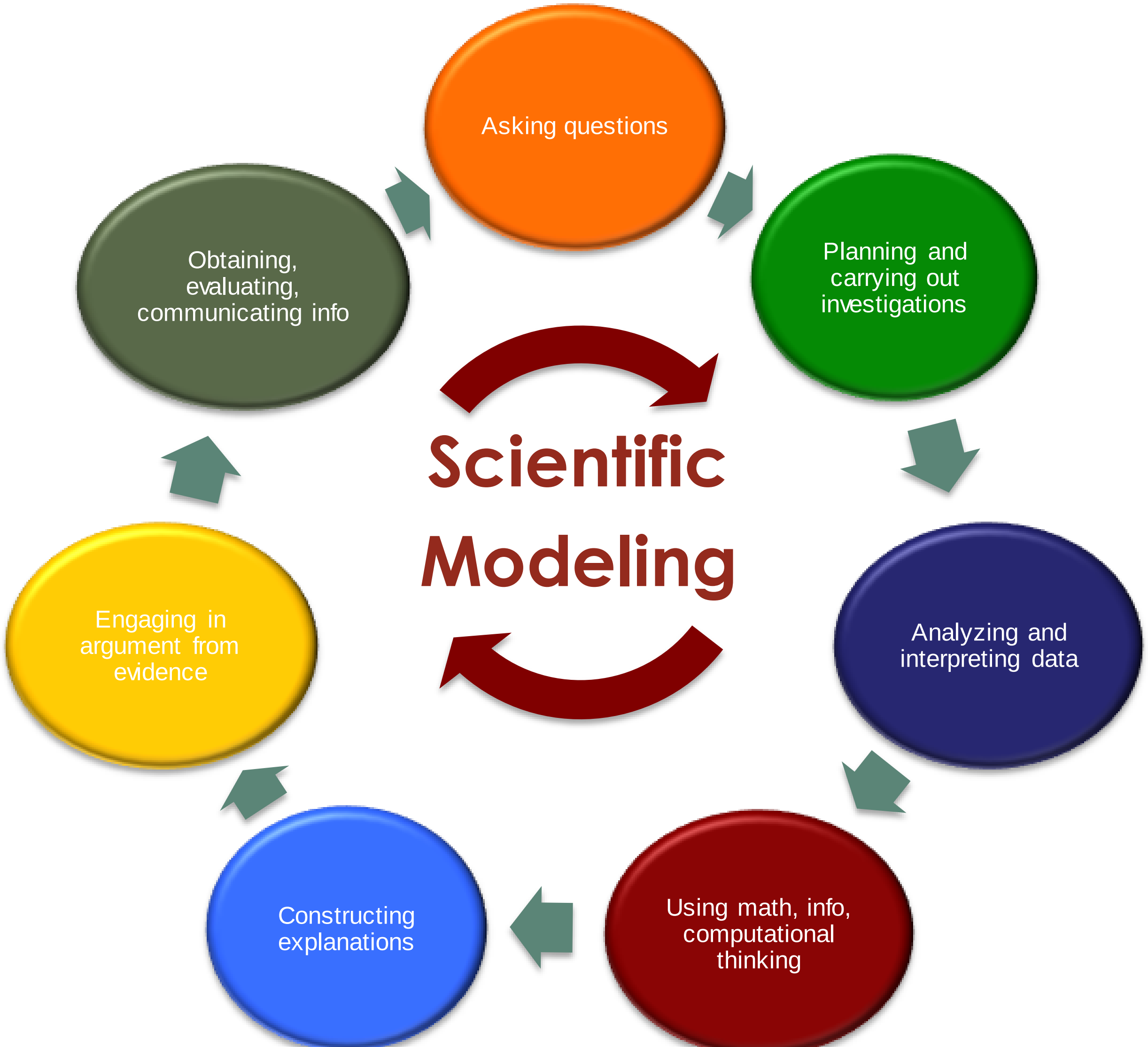
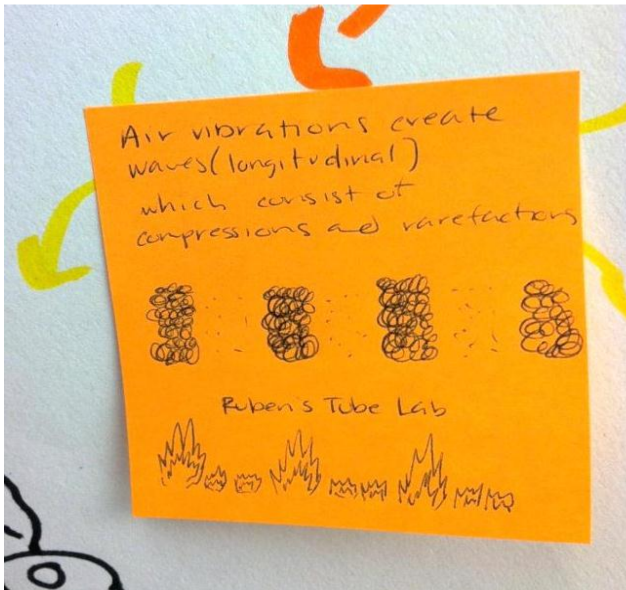
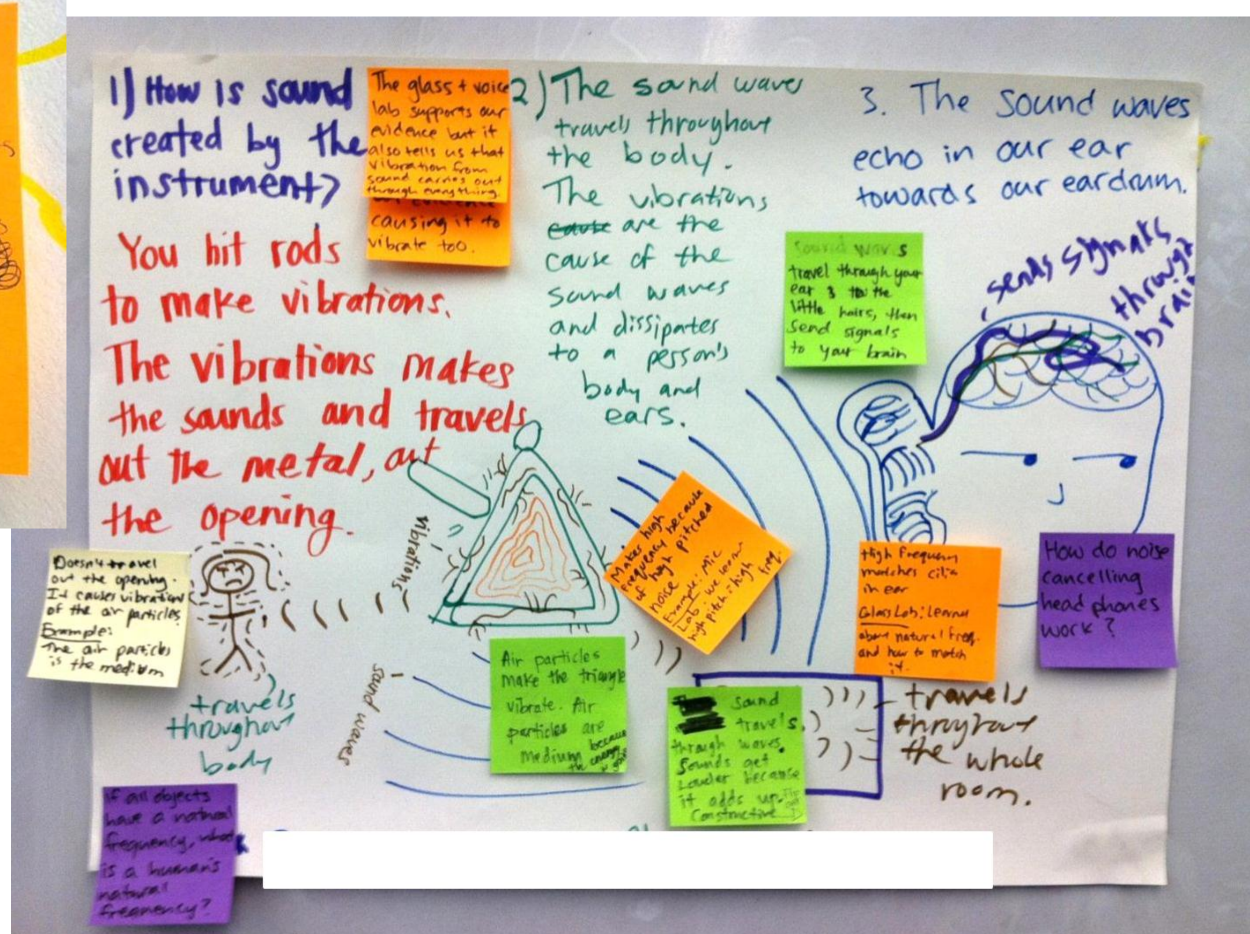
An Opportunity: *Next Generation* Standards



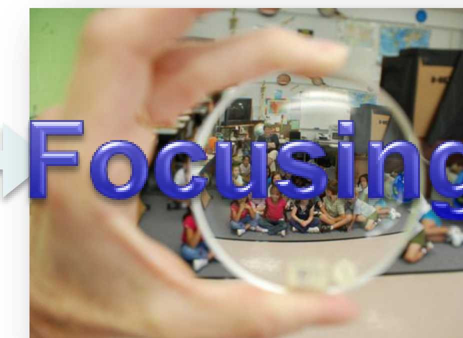
Co-development of face-to-face tools





Funneling vs. Focusing ideas in practice

High Rigor/Low Responsiveness 7%	High Rigor/ High Responsiveness 12%
Low Rigor/ Low Responsiveness 27%	Low Rigor/ High Responsiveness 8%



Building Within and Across Episodes

FYT	Episode 1-Warm Up 2-Instructions 3-Table Talk 4- Whole Class Discussion 5-Sharing Out 6-Gallery Walk 7- Seat Work 8-Content Injection 9-Closing	Rigor- teacher (explanation & big idea) NA- no talk 1- facts & procedures 2-what 3-how 4- why	Rigor- student (explanation & big idea) NA- no talk 1- facts & procedures 2-what 3-how 4- why	Responsiveness Building Scientific Ideas (BSI) NA- no talk 0-None 1- Responding 2- Building 3-New participation structures	Responsiveness Encouraging Participation & Building Community (PART) NA- no talk 0-None 1- Responding 2-Building 3-New participation structures	Responsiveness Cultural (STORY) NA- no talk 0-None 1-Responding 2- Building 3-New participation structures
CT 3 Bathtub explanation 12/10/10	warm up TC	1	na	0	0	0
	instructions TC	1	1	0	0	0
	table talk TC	1	1	1 (1.1)	0	0
	instructions TC	1	1	0	0	0
CT 3 D3 Na/Mg Expl. 11/19/10	warm up TC	2	2.5	1 (1.1)	1 (1.5, 1.8)	0
	Instructions TC	4	na	0	0	0
	table talk TC	2	2.5	1 (1.1, 2.1)	2 (2.5?)	0
	whole class TC	3	3	1.5 (1.1b, 2.3, 2.1)	2 (2.1, 2.5, 3.5)	0
	content injection TC	1.5	1	1 (1.1b, 2.1)	0 (1 example of 2.5)	0
	table talk TC	3	1	1 (1.1)	0	0
	whole class TC	3	2	1	1 (1.6)	0

S1: It splits water.

CT: Okay. So let's think about this. Felipe is telling us-

S2: What do you think is-?

S3: How are you going to be underwater and then spit out water? <<laughs>>

S1: Because I'm cool like that.

S4: The outside is a bubble, the inside is just air.

CT: <that these plants are making these bubbles and we had an interesting discussion over here about what is in those bubbles. So Felipe can you tell us why you think it's oxygen?

S1: because plants give out oxygen. And they're giving oxygen underwater and that's the bubbles.

CT: Okay. And Sebastian or and Isaac can you tell us a little bit more about what you're thinking about why do you think it's oxygen or what other experience do you have that makes you think that maybe that's oxygen? How do you know it's not just water bubbles?

S5: Because then it wouldn't in a bubble, when you're underwater and you blow out air it makes a bubble. It makes bubbles.

CT: Okay. So we know that bubbles form maybe when there's a gas that you're breathing out in water.

S6: What it's doing it like absorbing the water when it's in the light. It's absorbing the water and then just grabbing the H and putting away the O. And then the O comes together with another one and then it's released.

T: Thank you table 2, table 3? What did you find that was beneficial?

S1: They (microbes) eat other bacteria or protists.

T: They eat other bacteria or protists, anything else?

S1: They are in our food, like ice cream, and in toothpaste.

S2: What is beneficial about them being in ice cream?

T: Beneficial means positive, that they help us. They make it, ice cream, congeal together, like the agar we used on Thursday, made of protists. We can eat them or make products with them. **Raise your hand if you've eaten sushi or nori.** (Pause, many students raise hands) Then you've eaten protists. (Students respond with noise representing surprise). Shhhh…all right, anything that is harmful table 3?

S3: They can give you diarrhea.

T: They can give you diarrhea (BSI 1.1), they can make you sick. One protist called giardia, can give you diarrhea. Table 5, fungi…

Communities, Actors & Roles

Framing Problems

Classic Two-Worlds Model for Improvement of Teachers

5 of 23 TC-CT pairs

Competing influences and solving problems with ceilings—what to teach and how to teach it

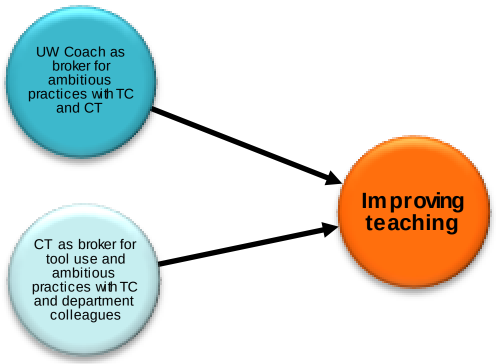
•CT did not view own practice as problematic

•Problems of practice: **Planning lessons using CTs scope and sequence while making space for ambitious teaching**

•To solve problems CT and TC use established tools (standard curriculum, textbook, district pacing guides)

Aligning Ambitious Teaching with Work in Schools for Improvement of Teaching

10 of 23 TC-CT pairs



Aligning ideas about practice and solving problems with ceilings—how to organize and design instruction

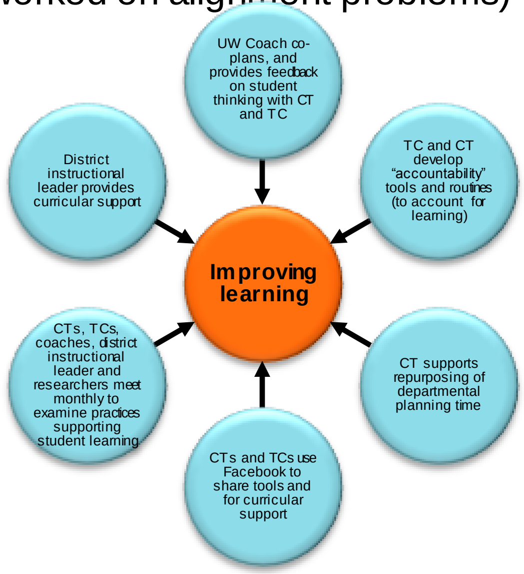
•CT as co-learner and broker of tools and ambitious practices

•Problems of practice: **Rearranging science units around scientific phenomena and tracking students' ideas**

•To solve problems CT and TC co-used tools
(as boundary objects)

Building a Networked Activity System for Improvement of Student Learning

8 of 23 TC-CT pairs (pairs also worked on alignment problems)



Building networks to make progress on problems without ceilings—how students learn

•CT as co-inquirer into student learning

•Problems of practice: **Unpacking scientific phenomena and calibrating with students' ideas**

•To make progress on problems TCs and CTs leveraged and created tools and routines across multiple communities