PennState
College of Education

DISCIPLINARY KNOWLEDGE FOR TEACHING: DETERMINING A THRESHOLD FOR BEGINNING PRACTICE

An Example from Science Education

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The Charge

- What disciplinary knowledge do beginning science teachers need to know?
- How would we decide whether novice teachers know this threshold level of content knowledge for teaching?
- What would it take to generate agreement about this threshold across programs and contexts?

In search of…

The Well-Started Beginning ~~Science~~ *Elementary* Teacher

Taken for Granted Ways of Thinking about Teachers and Teacher Education

Requires Disruption

Disrupt Deficit Framing of Elementary Teachers

Elementary Teachers as Superheroes


Good Morning!
Have a terrific day!
Week 9 vocab
1. apology (n)
2. prologue
pfe
pfe

Difficult and Complex Work

Multiple Subject Areas

Curricular Integration (and rule breaking)

ALL Children (all the time)

Knowledge Heavy, Practice Light

Challenge of Teacher Education

Grossman et al., 1999

Seeking Coherence: Disrupting Silos

Within and Beyond the University

Productive School Partnerships

Elementary Professional Development School (PDS)

Practitioner Inquiry as Signature Pedagogy

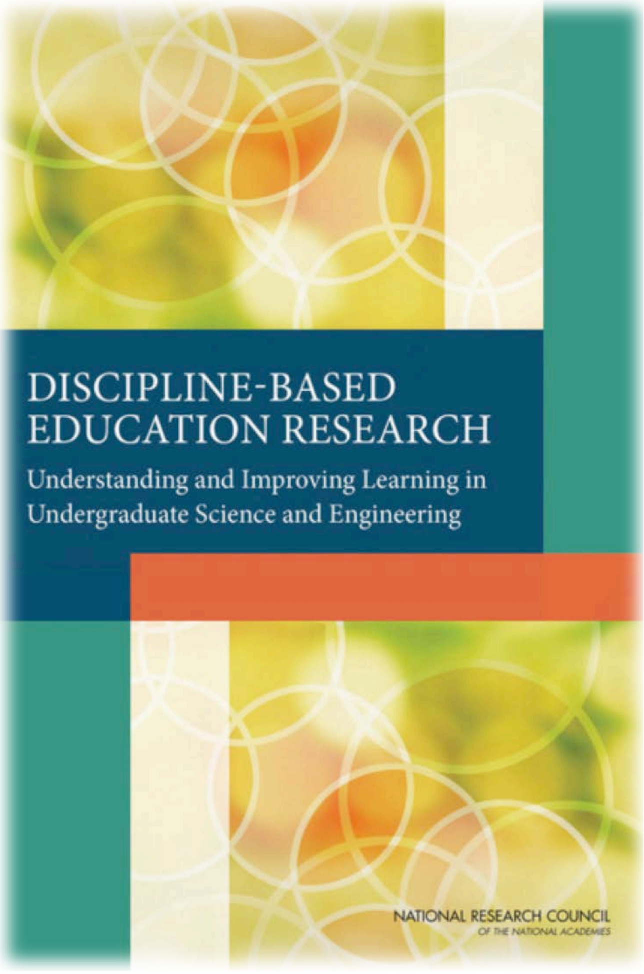
Disciplinary Knowledge in Science

What counts?

Past and Present

Disciplinary Knowledge in Science

- Science domains traditionally defined
  - Physics
  - Biological Sciences
  - Geosciences
  - Chemistry
- Engineering / STEM
- Blurred boundaries when applied to careers and emergent fields



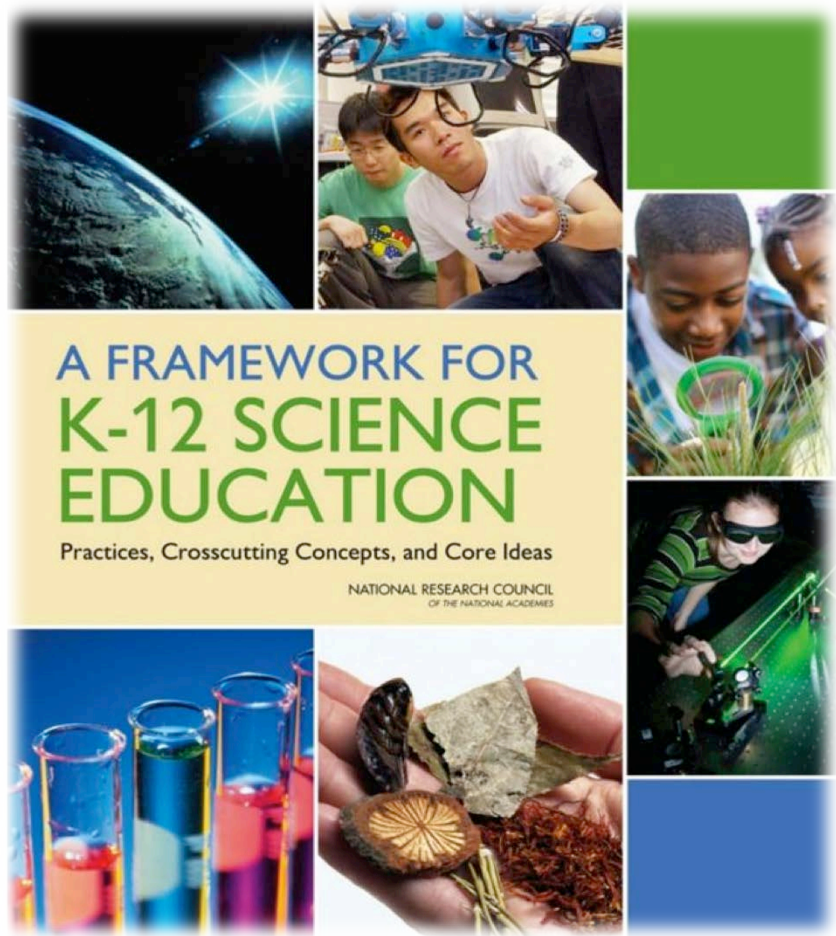
NRC 2012

Disciplinary Core Ideas

Life Science	Physical Science
LS1: From Molecules to Organisms: Structures and Processes LS2: Ecosystems: Interactions, Energy, and Dynamics LS3: Heredity: Inheritance and Variation of Traits LS4: Biological Evolution: Unity and Diversity	PS1: Matter and Its Interactions PS2: Motion and Stability: Forces and Interactions PS3: Energy PS4: Waves and Their Applications in Technologies for Information Transfer
Earth & Space Science	**Engineering & Technology**
ESS1: Earth's Place in the Universe ESS2: Earth's Systems ESS3: Earth and Human Activity	ETS1: Engineering Design ETS2: Links Among Engineering, Technology, Science, and Society

Framework for K-12 science education

- Ambitious vision for K-12 students' learning in science
- Three-dimensional learning
- Attention to engineering
- Not a prescription for science teaching



NRC 2012

Shifts in Science Teaching Practices

From science content to **3 dimensional learning**

- Facts ---> Big (Core) Ideas
- Skills ---> Practices
- Discrete ---> Connected

From science topics to explaining **phenomena** and answering questions

From teacher telling to **rich , dialogic classroom discourse**

- Making thinking visible
- Leveraging students ideas to move the lesson forward

From “activity-mania” to…

- Evidence-based scientific **explanations and modeling**
- Coherent sequence of learning opportunities

Three-Dimensional Learning

Students investigate, explain, and predict phenomena by adopting a scientific lens and using science ideas.

Science and Engineering Practices	Core Ideas	Crosscutting Concepts

3-LS3 Heredity: Inheritance and Variation of Traits

How to read the standards »
Go back to search results
Related Content »

Views: Disable Popups / Black and white / Practices and Core Ideas / Practices and Crosscutting Concepts / PDF

Students who demonstrate understanding can:

3-LS3-1. **Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.] [*Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.*]

3-LS3-2. **Use evidence to support the explanation that traits can be influenced by the environment.** [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS3-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Use evidence (e.g., observations, patterns) to support an explanation. (3-LS3-2)

Disciplinary Core Ideas

LS3.A: Inheritance of Traits

- Many characteristics of organisms are inherited from their parents. (3-LS3-1)
- Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2)

LS3.B: Variation of Traits

- Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1)
- The environment also affects the traits that an organism develops. (3-LS3-2)

Crosscutting Concepts

Patterns

- Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1)

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change. (3-LS3-2)

DCIs for Elementary Teachers (K-5)

Performance Expectations by DCI

Click on a topic to view associated performance expectations.

Elementary (K–5)

Storylines: K–2 3–5 PDFs: K 1 2 3 4 5

K-PS2 Motion and Stability: Forces and Interactions
K-PS3 Energy
K-LS1 From molecules to organisms: Structures and processes
K-ESS2 Earth's Systems
K-ESS3 Earth and Human Activity
1-PS4 Waves and Their Applications in Technologies for Information Transfer
1-LS1 From Molecules to Organisms: Structure and Processes
1-LS3 Heredity: Inheritance and Variation of Traits
1-ESS1 Earth's Place in the Universe
2-PS1 Matter and Its Interactions
2-LS2 Ecosystems: Interactions, Energy, and Dynamics
2-LS4 Biological Evolution: Unity and Diversity
2-ESS1 Earth's Place in the Universe
2-ESS2 Earth's Systems
K-2-ETS1 Engineering Design
3-PS2 Motion and Stability: Forces and Interactions
3-LS1 From Molecules to Organisms: Structures and Processes
3-LS2 Ecosystems: Interactions, Energy, and Dynamics
3-LS3 Heredity: Inheritance and Variation of Traits
3-LS4 Biological Evolution: Unity and Diversity
3-ESS2 Earth's Systems
3-ESS3 Earth and Human Activity
4-PS3 Energy
4-PS4 Waves and Their Applications in Technologies for Information Transfer
4-LS1 From Molecules to Organisms: Structures and Processes
4-ESS1 Earth's Place in the Universe
4-ESS2 Earth's Systems
4-ESS3 Earth and Human Activity
5-PS1 Matter and Its Interactions
5-PS2 Motion and Stability: Forces and Interactions
5-PS3 Energy
5-LS1 From Molecules to Organisms: Structures and Processes
5-LS2 Ecosystems: Interactions, Energy, and Dynamics
5-ESS1 Earth's Place in the Universe
5-ESS2 Earth's Systems
5-ESS3 Earth and Human Activity
3-5-ETS1 Engineering Design

Scientific & Engineering Practices

Asking probing questions and *defining problems*

Developing and using models

Planning and carrying out investigations

Analyzing and interpreting data

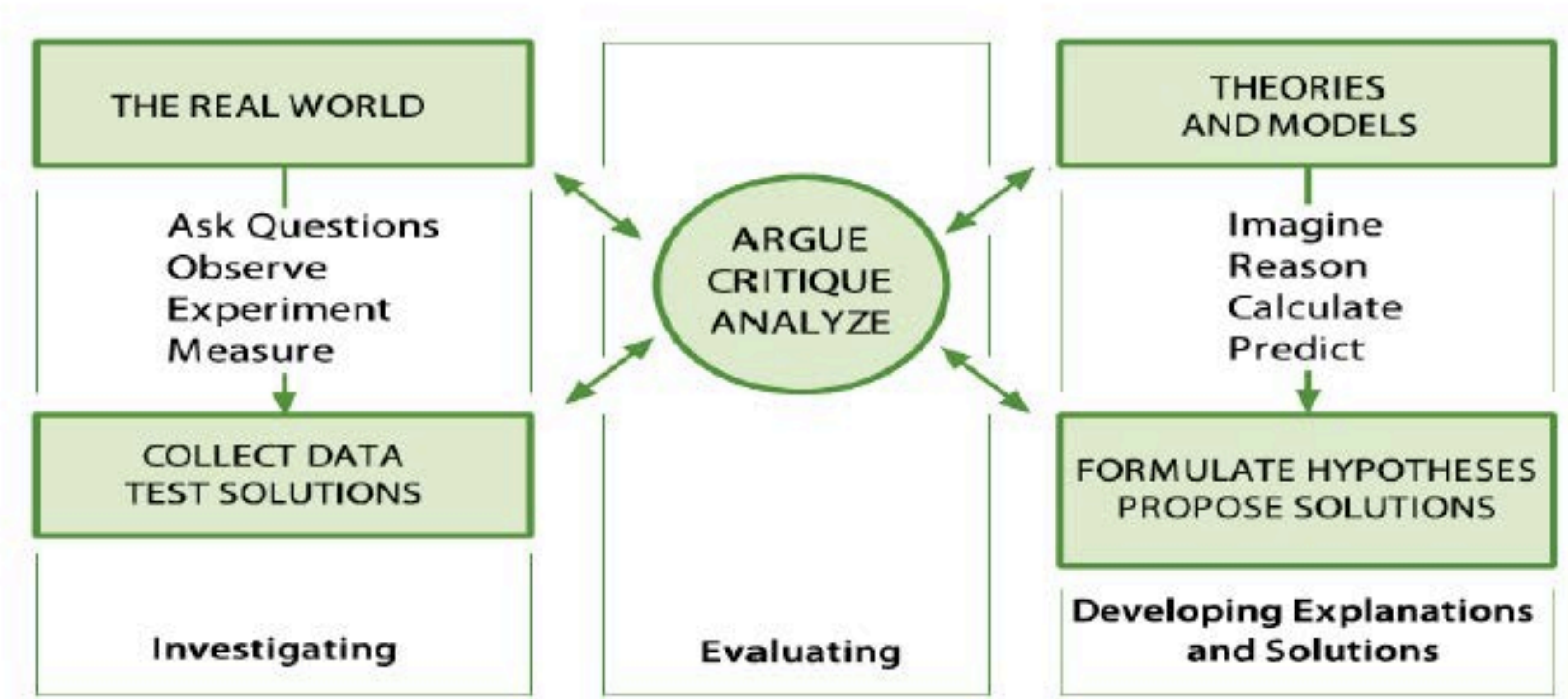
Using mathematics and computational thinking

Developing explanations and *designing solutions*

Engaging in argument from evidence

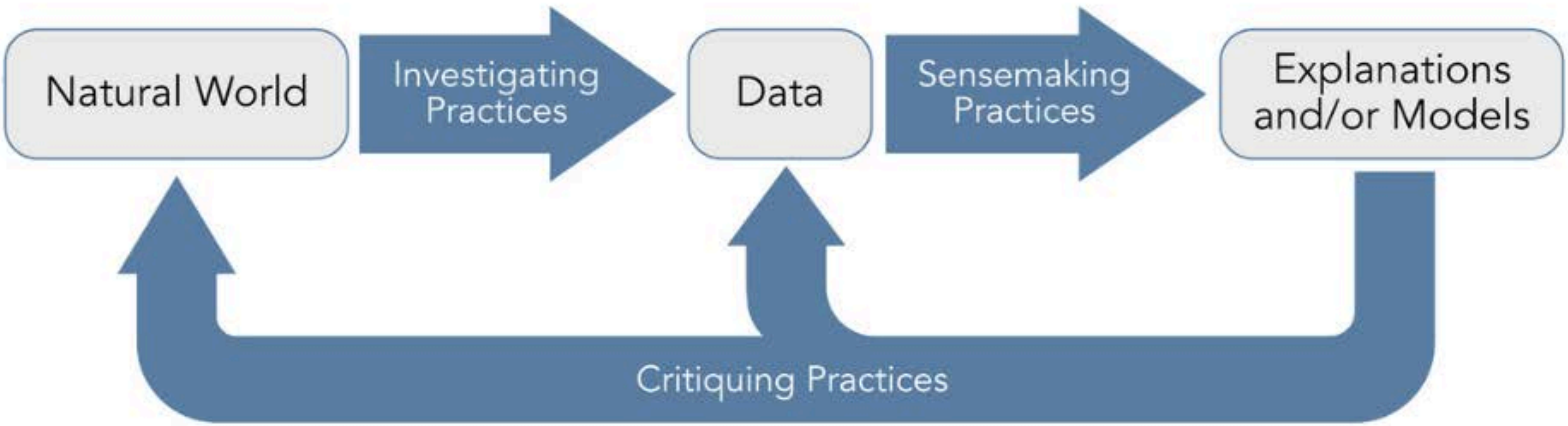
Obtaining, evaluating, and communicating information

Three Spheres of Activity for Scientists and Engineers



NRC, 2012

	Investigating Practices	Sensemaking Practices	Critiquing Practices
Science Practices	1. Asking questions 3. Planning and carrying out investigations 5. Using mathematical and computational thinking	2. Developing and using models 4. Analyzing and interpreting data 6. Constructing explanations	7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information



http://www.sciencepracticesleadership.com

Who is novice in the current context of reform?

Who is novice in the current context of reform?

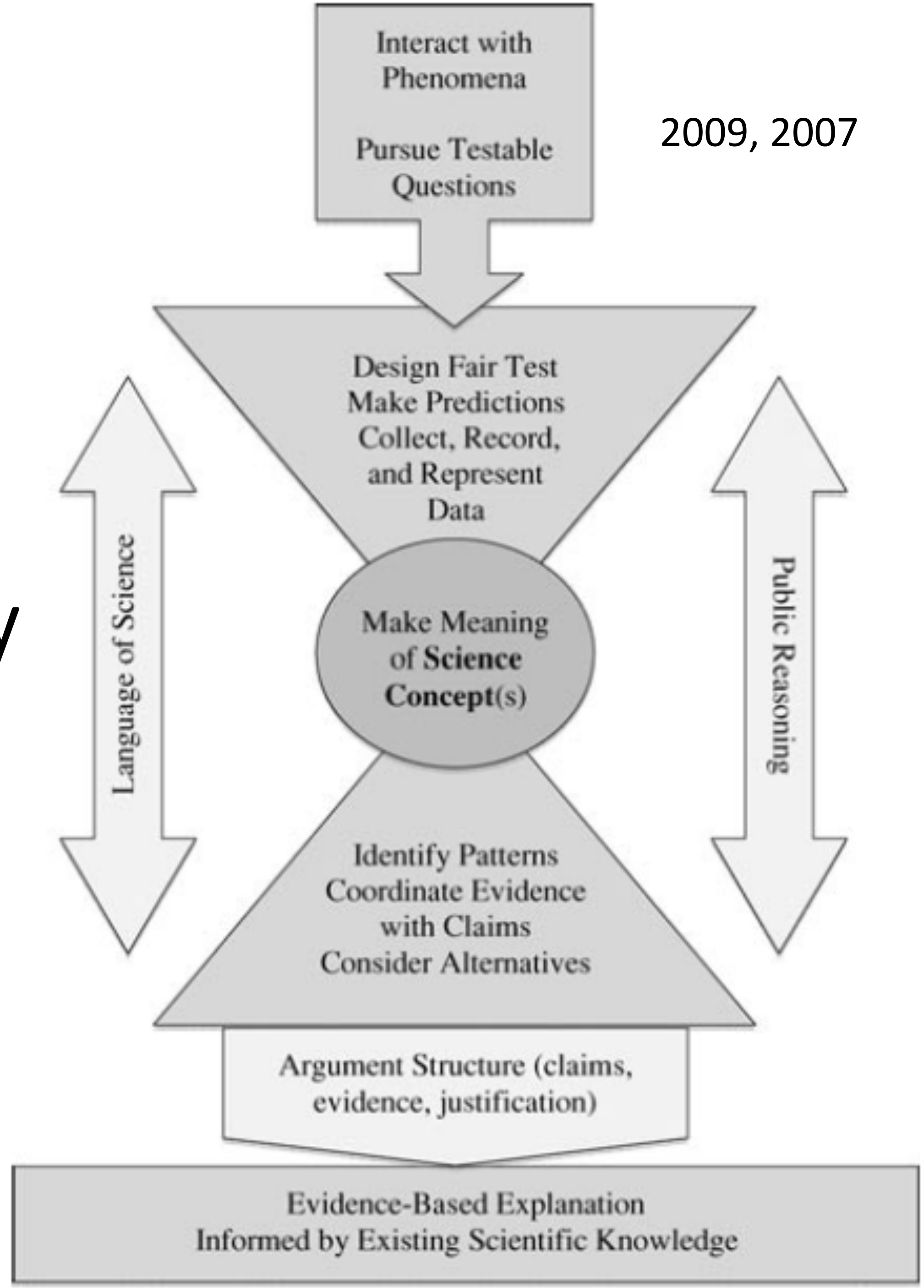
Most rendered novice in some way

Need for consideration across the professional continuum

Frameworks are Powerful

Grounding, Guiding, Coherence and Conversation

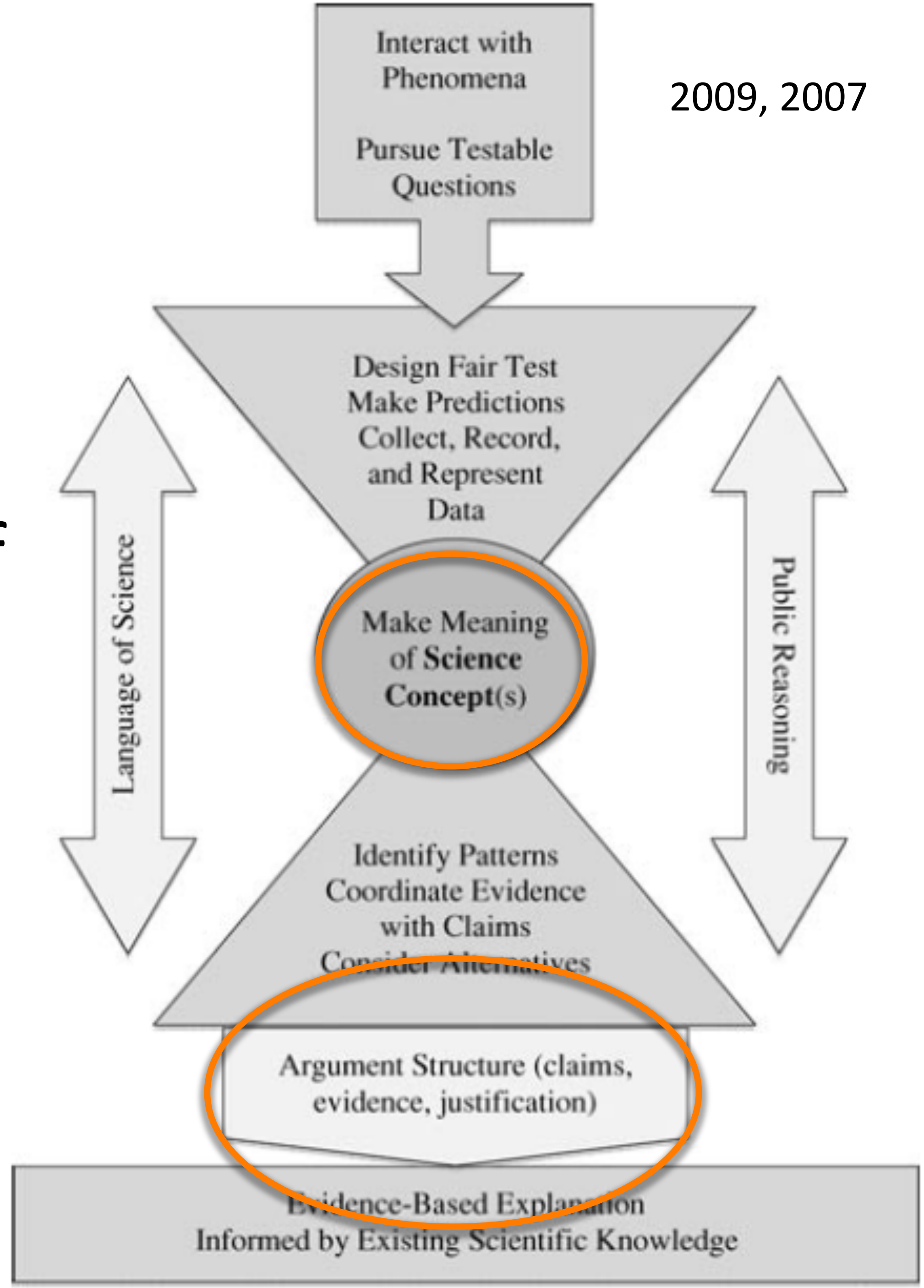
Framework for Teaching Elementary School Science as Argument



2009, 2007

Beyond the Litany of "Fun Activities"

(i.e, crafts and snacks)



2009, 2007

Scientific & Engineering Practices

Asking probing questions and *defining problems*

Developing and using models

Planning and carrying out investigations

Analyzing and interpreting data

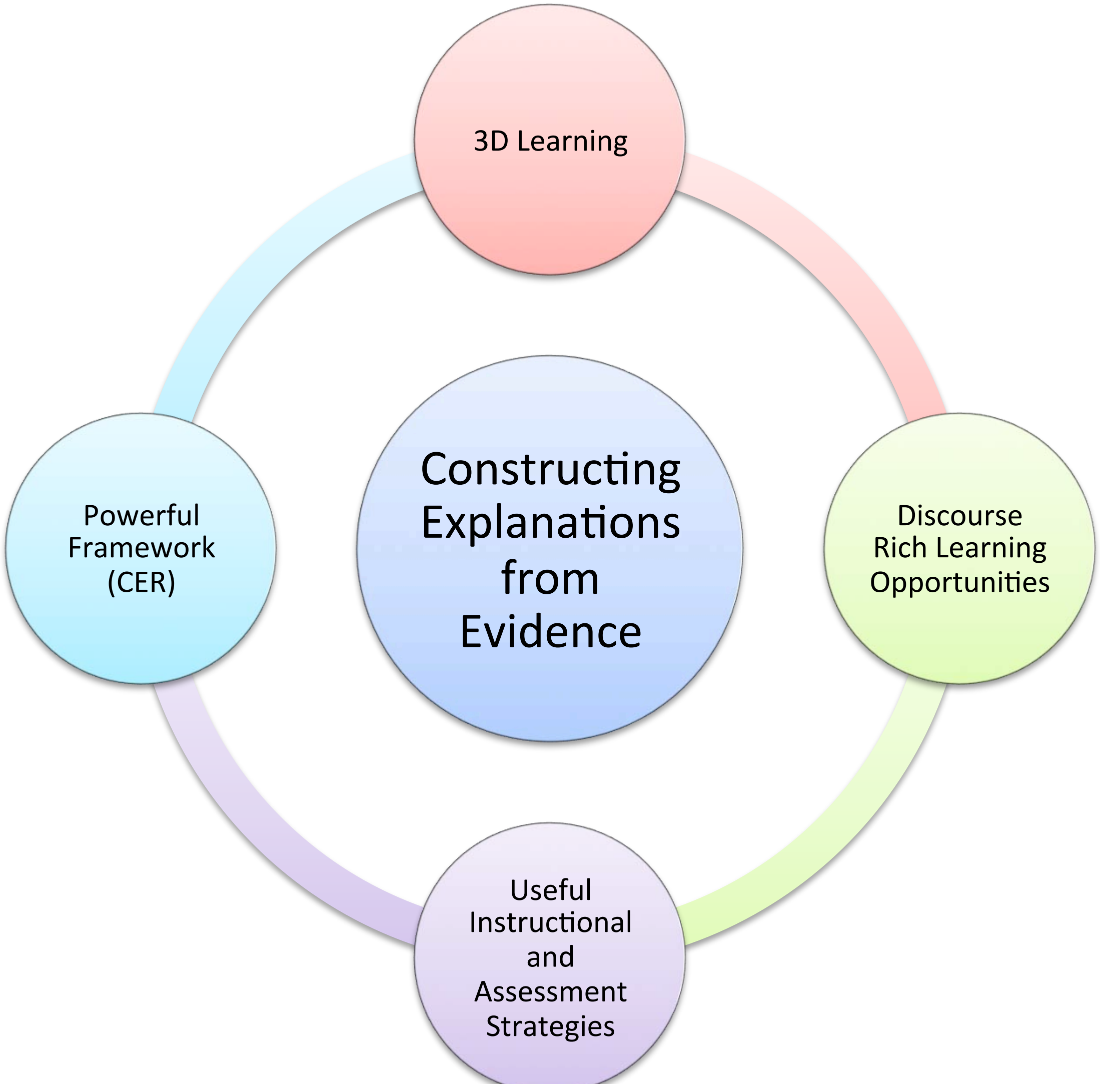
Using mathematics and computational thinking

Developing explanations and *designing solutions*

Engaging in argument from evidence

Obtaining, evaluating, and communicating information

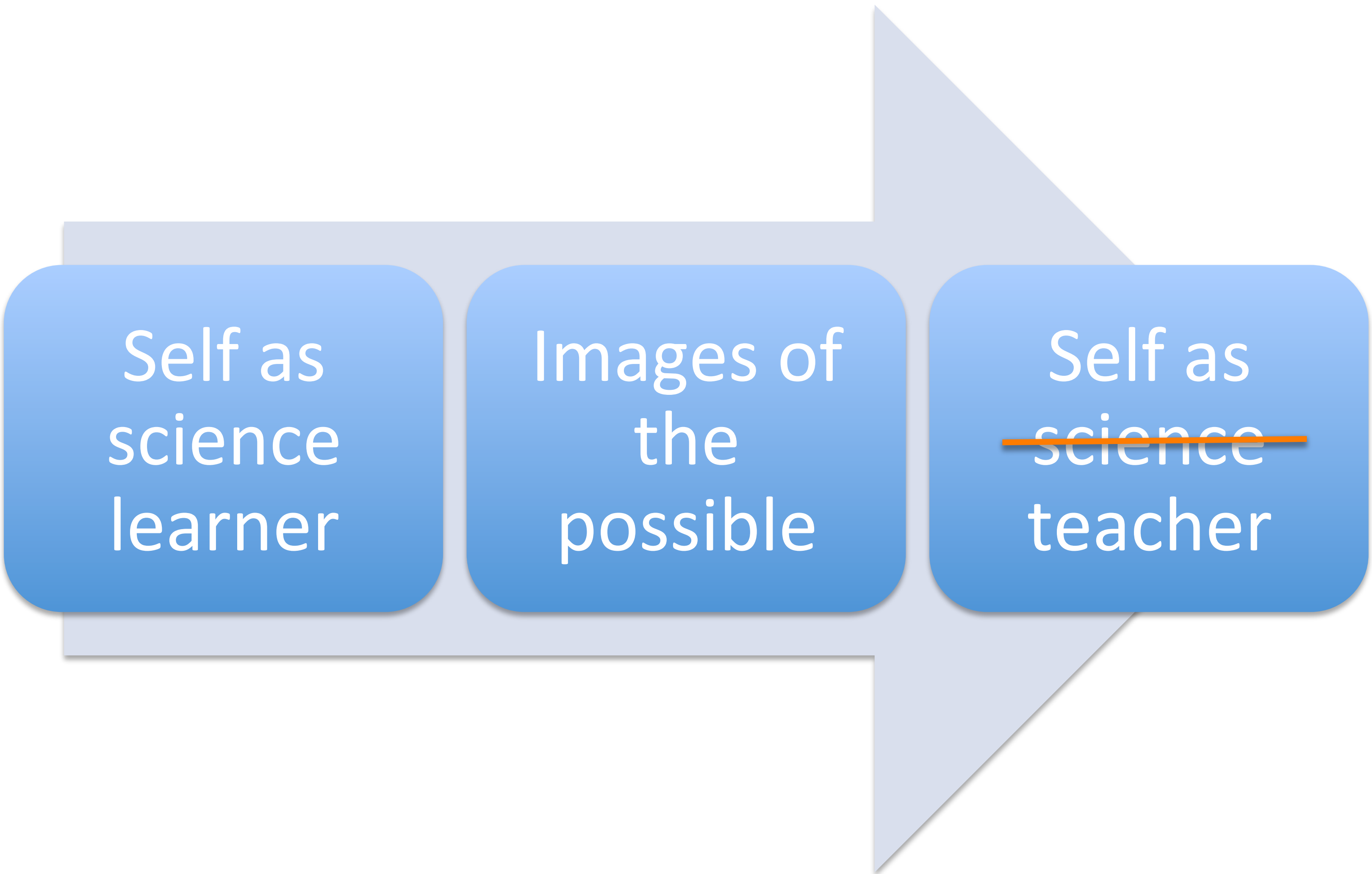
Powerful Scientific Practices



Content Knowledge for Teaching

With limited 3D science knowledge?

Learning to Support Children's Meaningful Science Learning

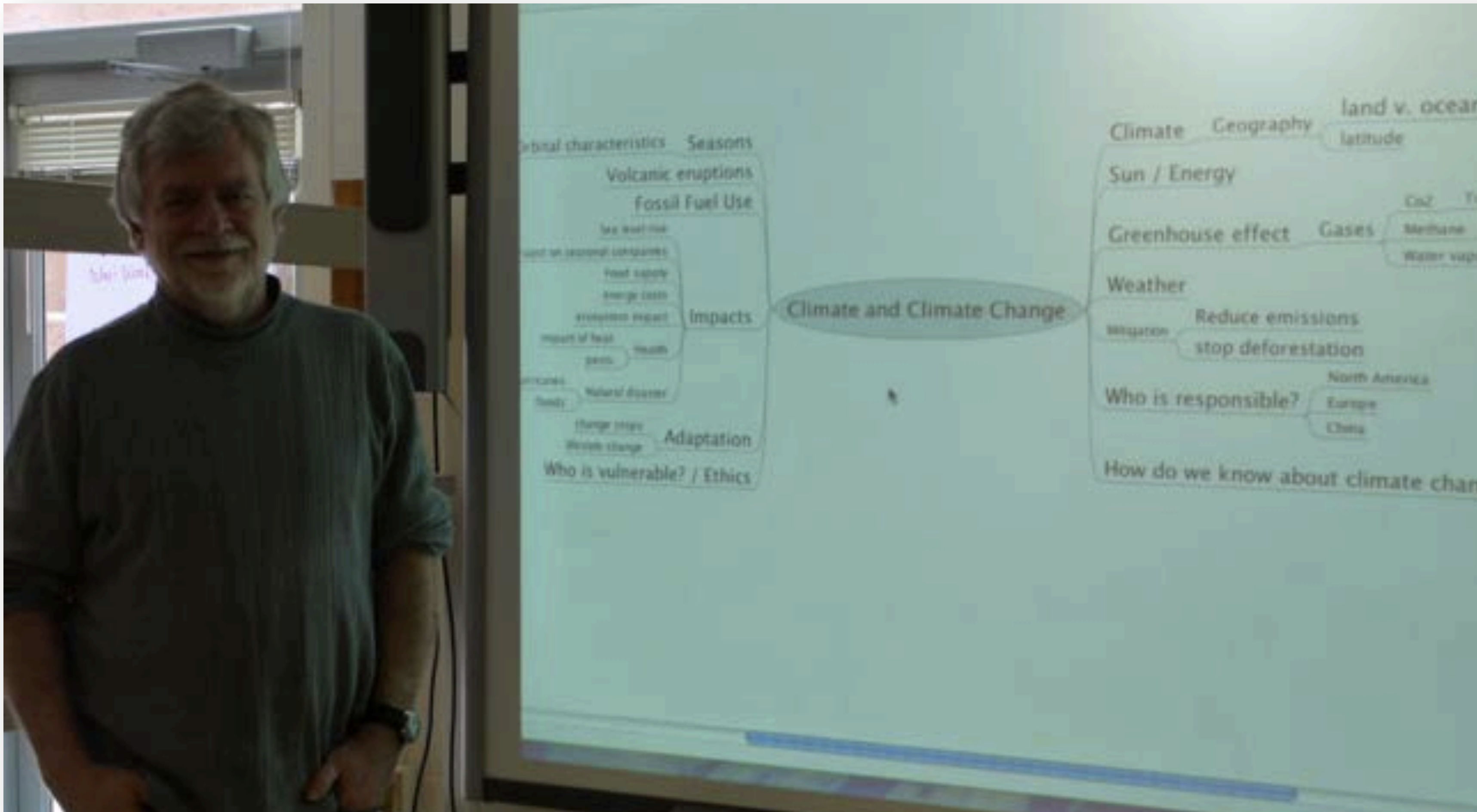


Subject Matter Serious

What is it like to learn science and about science in the ways in which one is expected to teach it?

Specialized Science Content Courses

Collaboratively Designed



Scientific Practices and Real Data

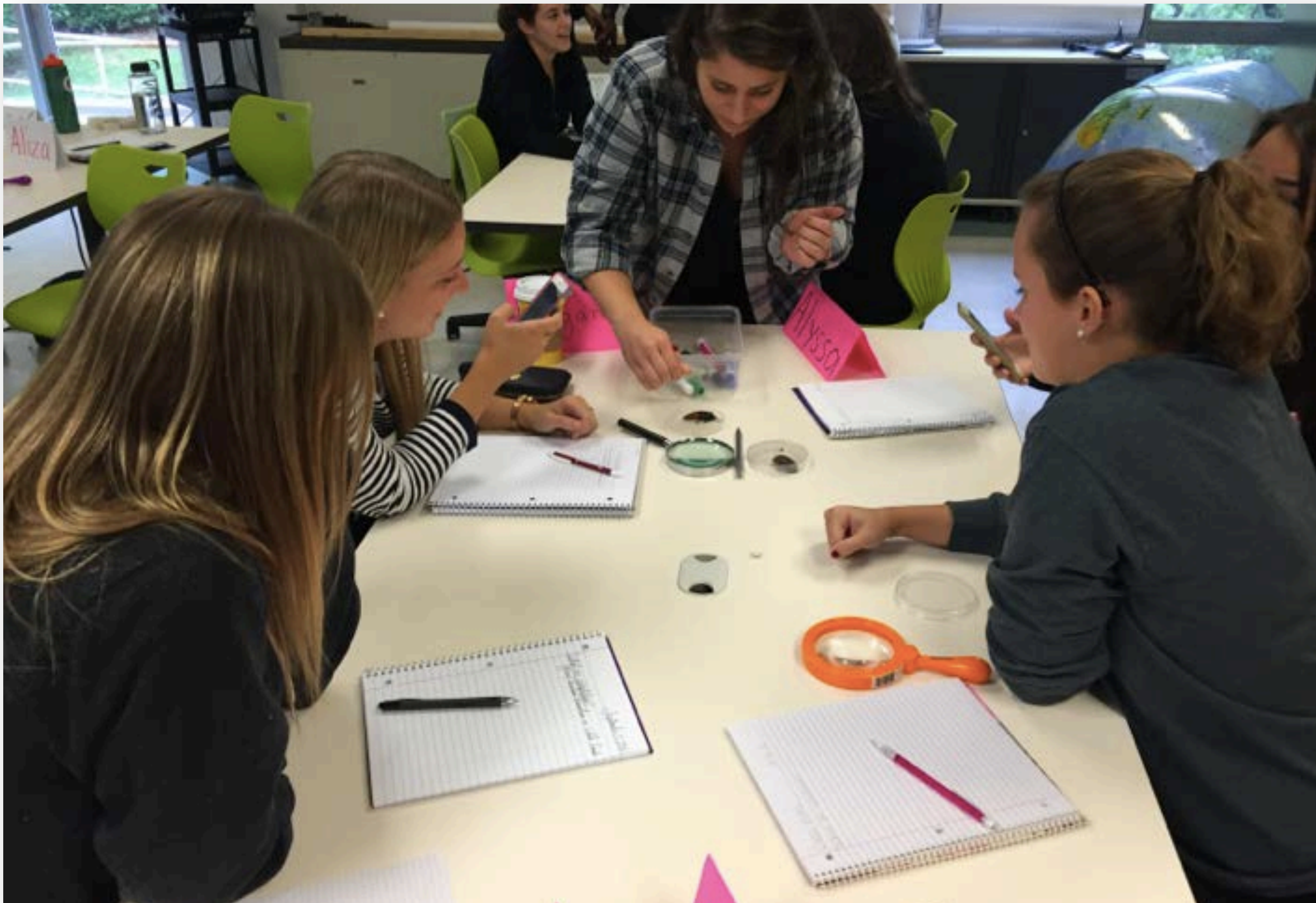
Opportunities to Consider CKT

What would you expect prospective elementary teachers to be like when they get to science methods and advanced field experiences?

What would you expect prospective elementary teachers to be like when they get to science methods and advanced field experiences?

Qualitatively "different" but not necessarily regarding subject matter knowledge

Science Learning & Teaching Course

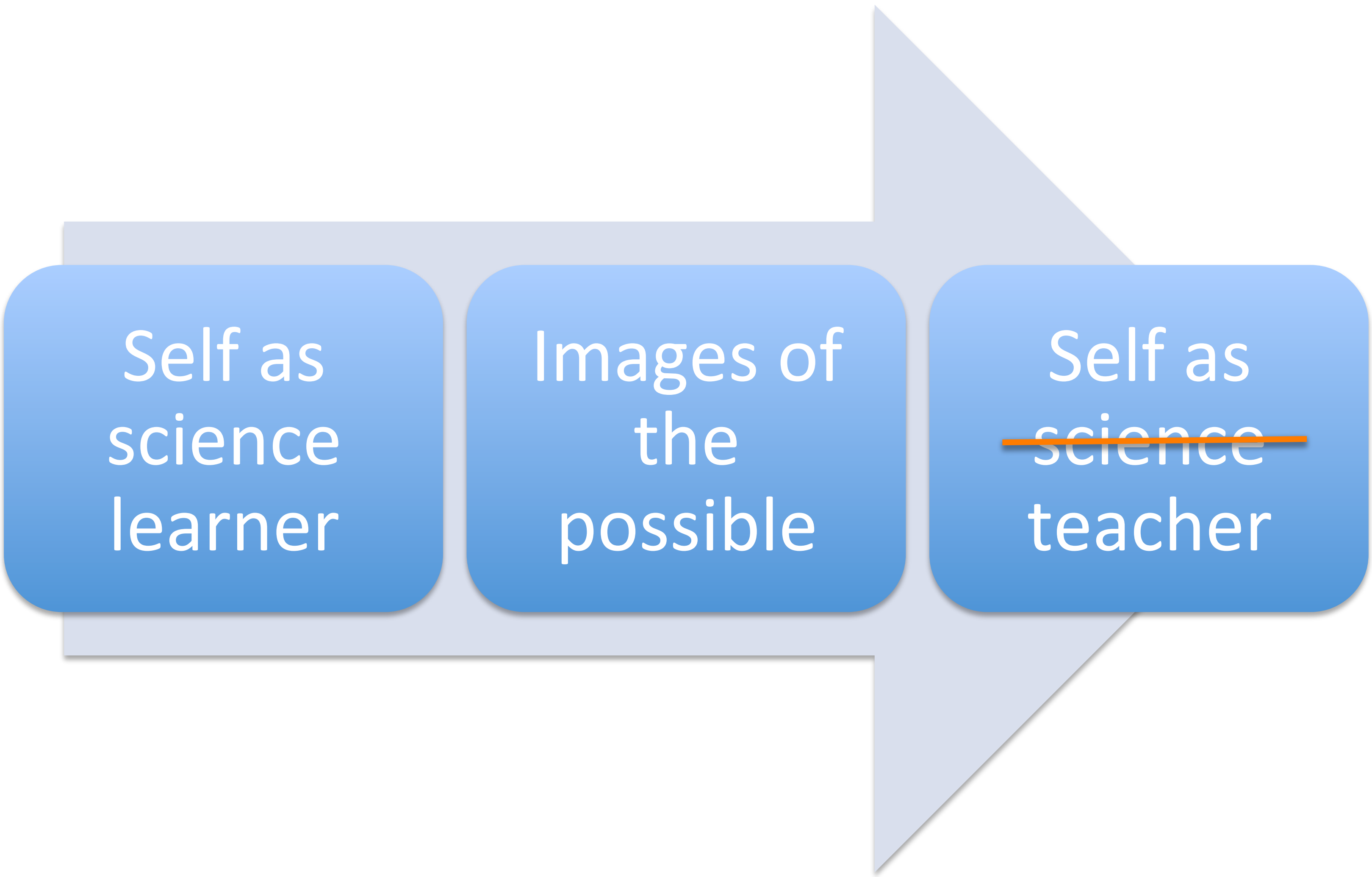


Goal of 3D Learning for Teachers in Science

One who knows how to engage with new subject matter

Scientific discourse and practices as a lever for learning

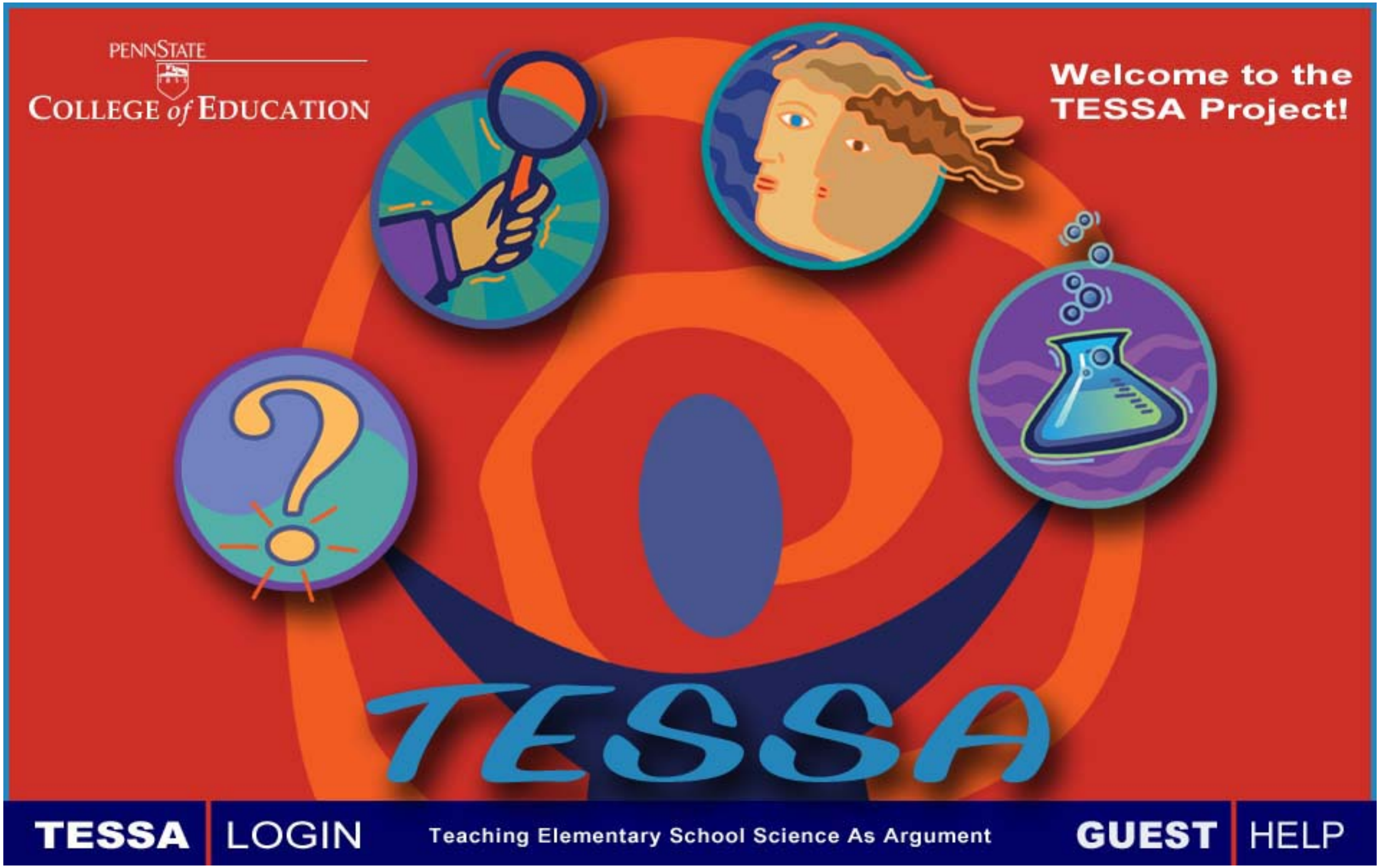
Learning to Support Children's Meaningful Science Learning



Video Analysis of Practice

A Powerful Pedagogy

Science Teaching Practices



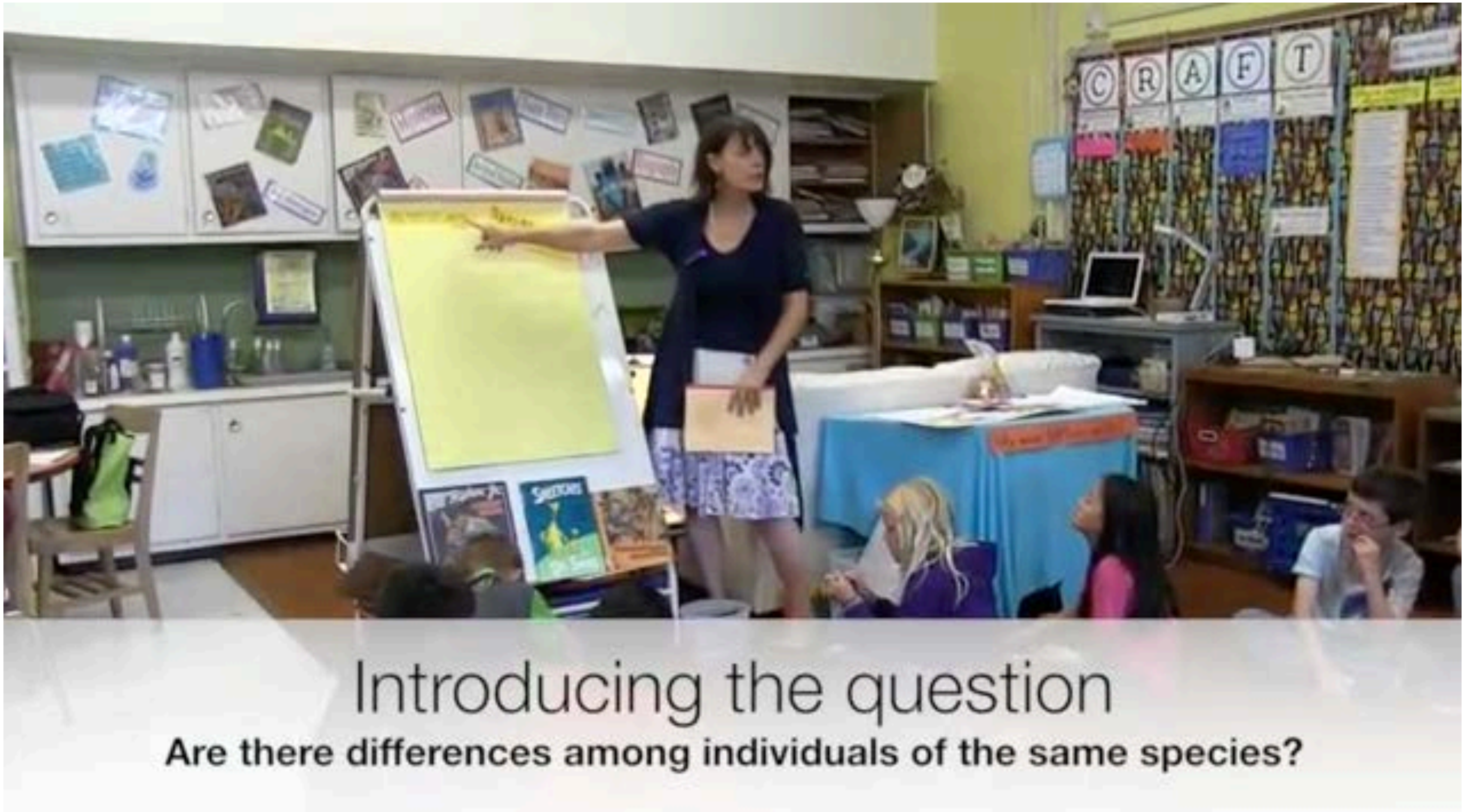
NSF CAREER 2003 - 2008

TESSA Goals

- Leverage the literature to construct a framework for teaching school science as argument
- Apply, study, and refine the framework
    - Online, video-based cases materials
    - Science content courses for prospective elementary teachers
    - Science methods coursework and field experiences
    - First years of teaching

Pivotal Shifts

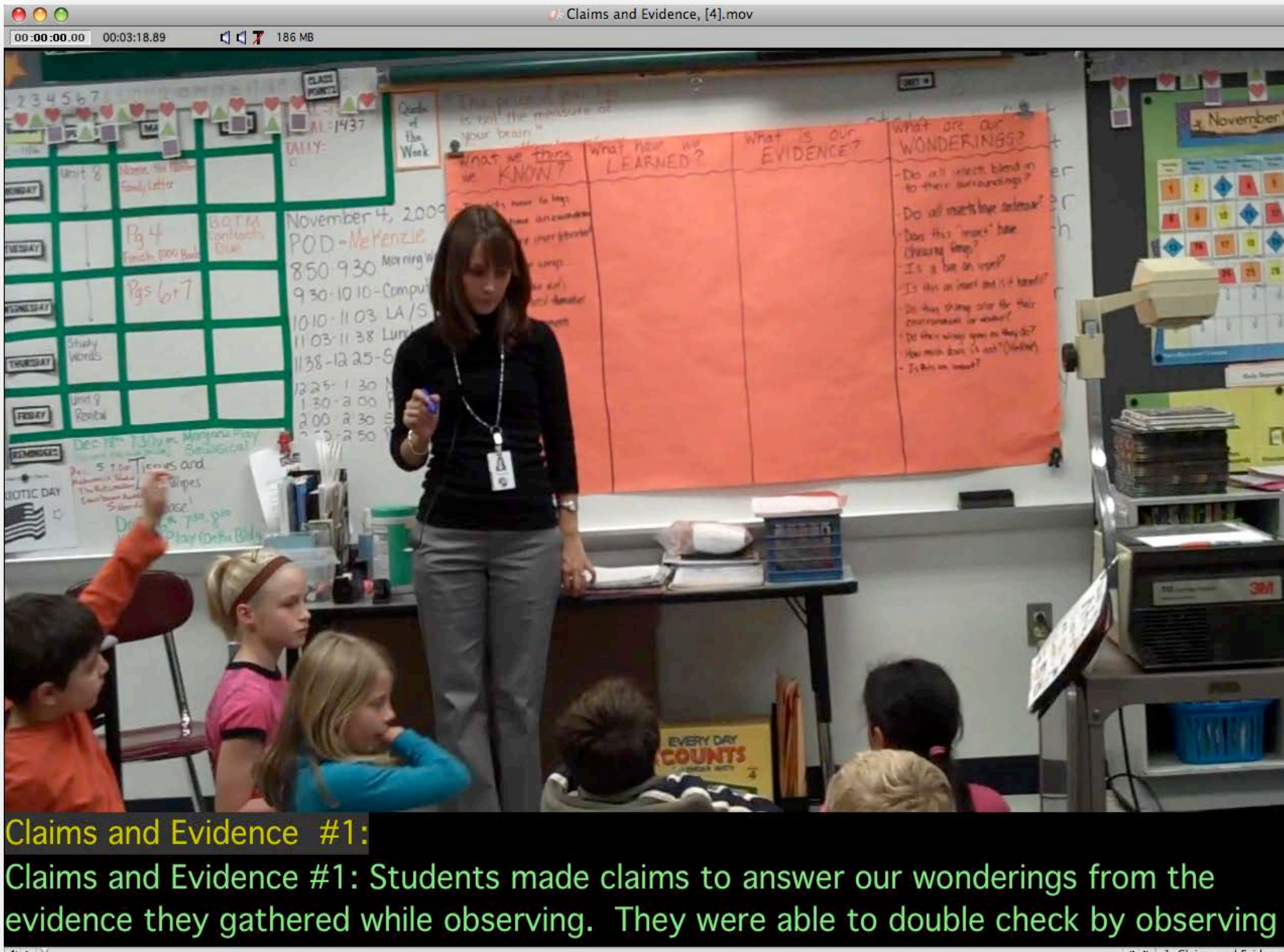
1) Disagreement can be productive in sense-making
2) Giving priority to evidence and explanations is essential to moving beyond activities in science
3) Prospective elementary teachers' science teaching practices reflected their framing



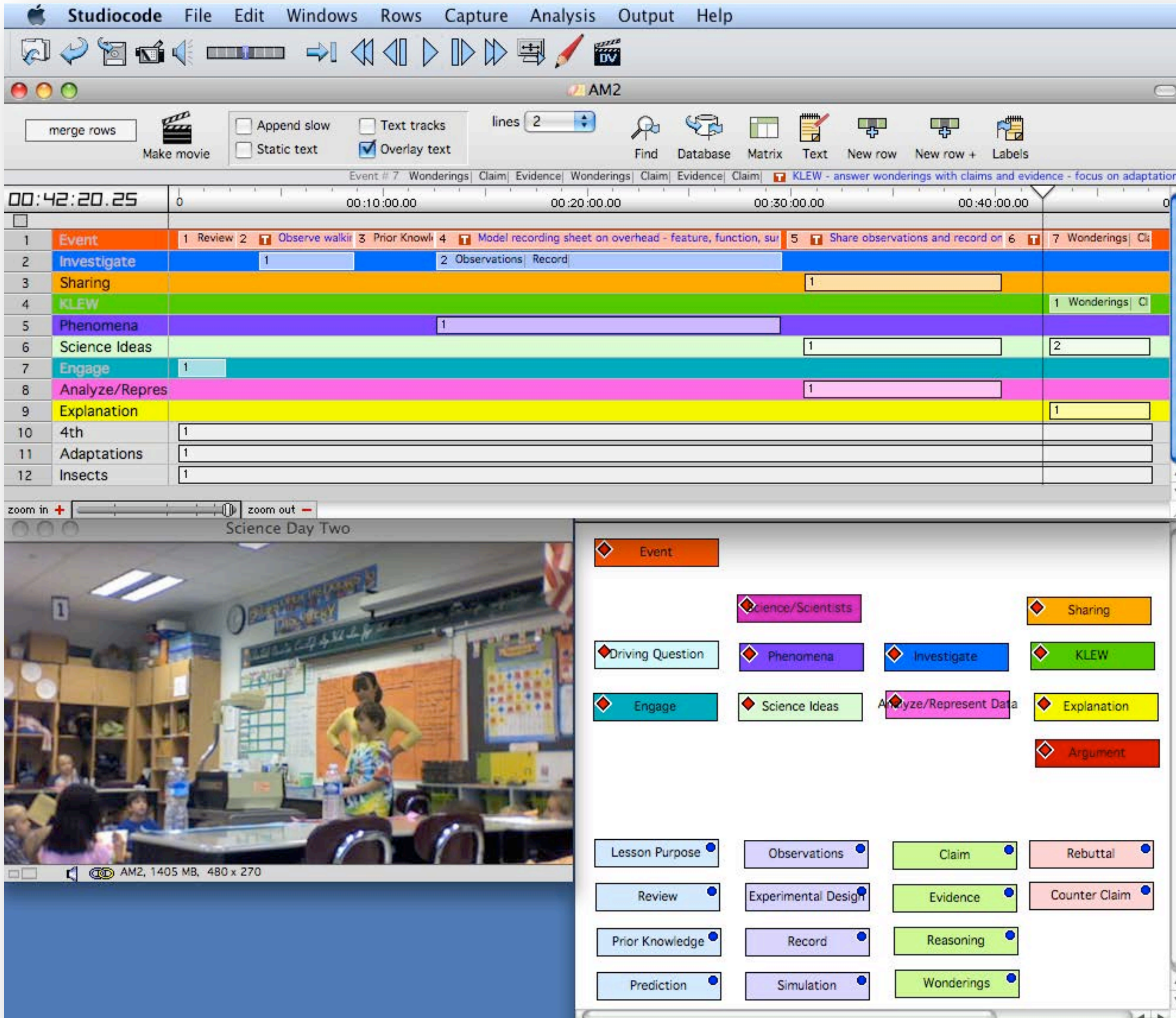
How does the teacher help students to construct a claim from evidence?

https://psu.box.com/s/sfe0d5ifljj7dtof68pxo

Content Knowledge for Teaching Science as Interactive and Contingent



Tools for Assessing the Analysis



Insights into Content Knowledge for Teaching

Participant	CANDY - 6th Grade	KATE - 4th Grade	LANA - 2nd Grade	MINDY - K
Teaching Topic	pH Testing - Acid, Base, Neutral	Insects and Adaptations	Insect Mouthparts	Light and Shadows
Science Ideas	Science ideas explicit - power of hydrogen; characteristics and testing for acids, bases, neutrals	Science ideas explicit, especially on Day 2 - connected feature, function, and survival advantage with adaptation	Science ideas implicit - no mention of adaptations, but a focus on form and function with insect mouthparts	Science ideas implicit, except during explanation building
Phenomena	Opportunities to engage with phenomena in relation to science ideas (three tests for pH on multiple substances)	Opportunities to engage with phenomena in relation to science ideas (observe insects for form and function; simulation for camouflage and change in population over time)	Some opportunities to engage with phenomena on day two (direct observations of insect mouthparts and video observations)	Opportunities to engage with the phenomena (indoor/ outdoor scavenger hunt and shadow stations)
Explanation	Straightforward attempts to construct explanations; driving question focused on figuring out which substances were A/B/N and which tests were most reliable and practical	Sophisticated attempts to construct explanations; claims constructed in relation to students' questions; supporting evidence appropriate; some claims are problematic due to science content knowledge issues	Claims are about how insects use their mouthparts to eat and which simulated tool is most similar; issues with what counts as evidence on Day 1; no driving questions to organize instruction	Solid attempts at getting students to generate claims about shadows and provide evidence from stations and scavenger hunt; claims connected to the general question of what did we learn about shadows?
Mapping Claims and Evidence	No KLEW chart; claims and evidence recorded on a class chart; claims were a list of which substances were A/B/N and evidence was pH	KLEW chart used completely to record prior knowledge, wonderings, claims and evidence; claims constructed in response to student questions	KLEW chart used completely to record prior knowledge, wonderings, claims and evidence	KLEW chart used completely to record prior knowledge, wonderings, claims and evidence; record on post-its then transfer to chart
Discussion	Discussion included after each test (or embedded as in Day 2 demonstration of probes) to group substances into A/B/N categories based on evidence from pH tests	Discussion included after each activity/investigation; focus on either generating questions (Day 1) or sharing observations and constructing claims from evidence; use of teacher questions to guide toward claim/evidence	Discussion included after each activity/simulation; sharing observations guided toward constructing claims from evidence through teacher questioning	Discussion included after each activity and stations; sharing observations guided toward constructing claims from evidence through questioning

Insights into Framing of Science Teaching

Participant	CANDY - 6th Grade	KATE - 4th Grade	LANA - 2nd Grade	MINDY - K
Activity Analysis	Selected clips show students testing across all three methods; attention to prediction, testing, recording, and making claims based on results; explicit about students being actively engaged, using equipment correctly, and comparing predictions with prior data for related substances	Selected clips show students engaged in observing insects and the simulation; attention to questioning and using them to keep students on track to eventually construct claims from evidence; talks about the simulation as collecting data; addresses her guiding role in using observations to generate wonderings on Day 1 that would frame activities on Days 2 & 3	Selects clips show students actively engaged in activities; mentions the importance of making connections across stations on Day 2 and back to Day 1; heavy focus on the questions being asked to help students notice key features of insect mouthparts, etc.; no mention of observations serving as evidence for the construction of claims	Selected clips show students actively engaged in investigating shadows; teachers are asking appropriate questions to get students to notice important aspects of the phenomena; no mention of observations as evidence for constructing claims
Explanation Analysis	3 key clips; all consistent with coded events; one event demonstrates prompting students for more evidence; another focuses on the importance of multiple sources of evidence and consistency of results across tests; notes that taken together these things increase confidence in claims	4 key clips; all consistent with coded events; heavy and repeated emphasis on constructing claims from evidence and responding to student wonderings; notes intentionally asking students for their evidence; uses science ideas in her analysis; addresses talk norms (students ready to respond to the question about evidence)	4 of 9 clips connected to whole group discussion; 2 of these clips related to coded events; focuses on questions used to get individual students to explain and the fact that she does not tell students the correct answers; points out scientific terms, but never mentions science ideas; never mentions KLEW or claims/evidence	Only one strong reference to claims/evidence and the KLEW chart; 2 of 5 clips align with coded events; heavy emphasis on individual children v. the group; attention to group focused on generic sharing

Research AND Practice

Assess Longitudinal Development

(Re)design of Learning Opportunities

Raises New Questions

Coherence is Consequential

Framing involves foregrounding, which necessarily requires moving some things to the background.

So what framing should be foregrounded?

What are the unintentional consequences of particular kinds of framing?

Who is the well-started beginner?

Informed by Powerful Frameworks

Committed to Continued Inquiry and Learning

Dedicated to ALL Children

Consensus is Illusive

Track Record in Science Education
and in Teacher Education

Call to Action

AERA Panel Report 2005

Studying Teacher Education

- Research on *pedagogy of teacher education* is relatively new (p. 450)
- "Plethora of pedagogies" likely reflect different conceptions of teaching practices (p. 429)
- Toward a research program on the pedagogies of teacher preparation (p.451)
  - Articulated theory of teacher learning that cuts across pedagogical approaches; guide research and frame interpretation of findings
  - Common "toolkits" for researching teacher learning; build on one another's work
  - More precise language to talk about pedagogies

Grossman, 2005

Plethora of Practices?

Pedagogical Practices

High-Leverage Practices

Science and Engineering Practices

Pockets of Innovation

…and business as usual

Productive Engagement in Discourse about Teacher Preparation in Science

Where do we go from here?

Elementary Science Teacher Education

Science Education

Edited by John L. Rudolph

Impact Factor: 2.825

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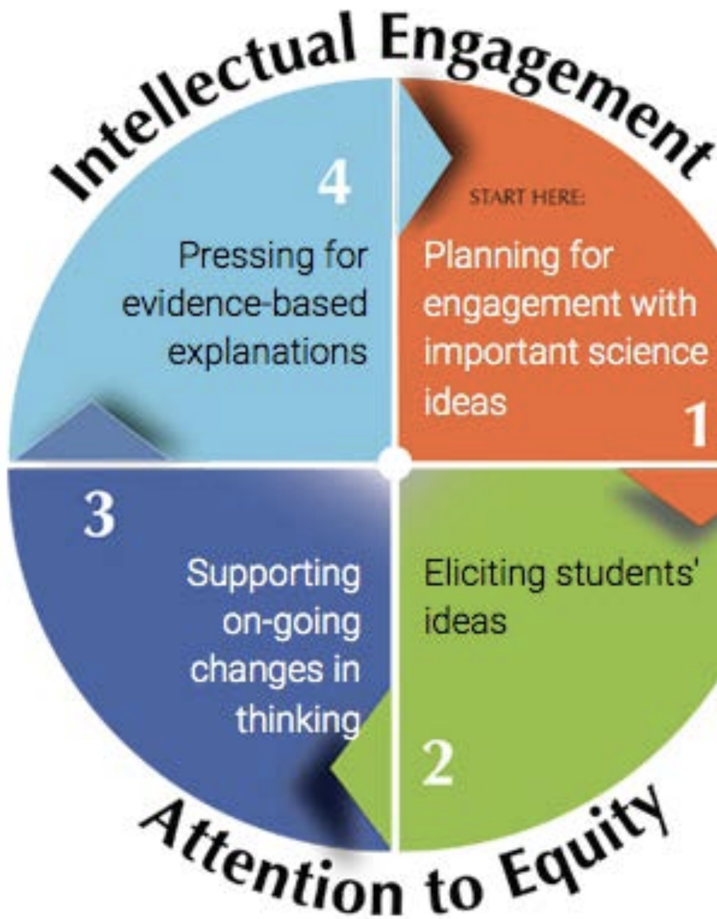
Online ISSN: 1098-237X

- Principled reasoning about problems of practice
- Across institutions, programs, and frameworks
- Anderson, Davis, Mikeska, Schwarz, Smithey, Zembal-Saul

Tools for Ambitious Science Teaching



- Windschitl and colleagues
- Framework, tools, community with distributed expertise
- Articulate ambitious science teaching practices and pedagogies of practice
- AERA Handbook of Research 2016

http://ambitiousscienceteaching.org/

Making the Work of Teacher Education Public

Goals and Purpose
Design and Infrastructure
Approaches and Artifacts
Impacts and Challenges
Sustainability and Scholarship
Create Community

The Time is Now

- Call for shared language, tools, and theory for design and research on teacher preparation
- Theoretically grounded attempts to talk across programs
- Organizations and funded projects aimed at examining the relationship between pedagogies and features of professional practice; identifying, implementing, and studying high-leverage teaching practices
- Collaborative work between universities and national professional organizations (e.g., AACTE, AERA)
- **SOCIAL JUSTICE IMPERATIVE**

Let’s get to work!

Discussion

Gratitude

For your productive influence on my thinking and practice and for your leadership in the field of teacher education