

We Make the Road by Walking

The University of Auckland

Faculty Seminar

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Strategic Literacy Initiative, WestEd



PROJECT **READi**

Reading, Evidence, and Argumentation in Disciplinary Instruction

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Genesis of Project READI

\$120 million Reading for Understanding Initiative

- Call from U.S. Department of Education, Institute for Education Sciences in 2009 for a network of teams investigating *reading for understanding*, with the aim of identifying and intervening in malleable factors influencing students' proficiencies.
- Definition of *reading for understanding* left to proposers.

PROJECT **READi**

A multidisciplinary, multi-institution collaboration of researchers, professional development designers and facilitators, and practitioners

- Distinctive aspects of Reading for Understanding Initiative:

- Multidisciplinary teams to conduct basic research and design and test interventions over a 5 year period
- Projects expected to carry out “rapid prototyping” based on promising practices
- Collaboration with educational practitioners required to assure feasibility of interventions
- Teams required to address reading for understanding over a 5 year age/grade span and across multiple subject areas
- Interventions would be tested using rigorous randomized, controlled efficacy trial

Project READI definition of reading for understanding:

- Focuses on evidence-based argumentation from multiple text sources as a means for building deep levels of comprehension
- Recognizes the role that disciplinary practices have in reading comprehension
- Three disciplines: history, English language arts, and science
- Grades 6-12

• Rationale

- Importance of reading to learn/acquire information from multiple information sources in academic, professional, and personal life
 - Requires specialized reading, critical thinking, and communicating practices (Alvermann & Moore, 1991; CCSSO, 2010; Goldman & Bisanz, 2002; Lee & Spratley, 2010; Moje, 2008; Snow & Biancarosa, 2003)
- National and international indicators showing that current educational practices are not producing citizens with these skills
 - They are ill-prepared for 21st century
- Evidence-based argument is a cornerstone of disciplinary practices and knowledge generation in all three subject-matter areas

- Sources

- Expanded definition of traditional text to include multiple modes of communication characteristic of discourse in disciplines (Kress, 1989; New London Group, 1996)

- Evidence-based argumentation

- Making a claim or assertion that is supported by evidence that connects to the claim in a principled way (Toulmin, 1958)

- Nature of claims, evidence and principles differ depending on the discipline.

- Disciplines are discourse communities that negotiate discourse norms and shared understandings about valid forms of argument (Gee, 1992; Lave & Wenger, 1991)

Theory of Action/Change

- Teachers mediate interventions intended to provide opportunities to learn for students.
- Most teachers have not themselves had opportunities to engage in disciplinary evidence-based argumentation
- READI Intervention development proceeded at teacher as well as student learning levels
 - READI Teacher Inquiry Networks: Professional Learning Communities
 - Evidence-based Argument Instructional Modules

Project READI Members

- *Carolyn Aguirre
- Michael Bolz
- Stephen Briner
- M Anne Britt
- Willard Brown
- Jim Buell
- Candice Burkett
- *Jessica Chambers
- *Elizabeth Childers
- Irisa Charney-Sirott
- Gayle Cribb
- *Rick Coppola
- Angela Fortune
- MariAnne George
- Susan Goldman
- Cynthia Greenleaf
- Thomas Griffin
- *Jenny Gustavson
- Gina Hale
- Allison Hall
- *Johanna Heppler
- *Jodi Hoard
- Katie James
- Rita Jensen
- *Adriana Jaurequy
- Monica Ko
- Kim Lawless
- Carol Lee
- *Rachel Letizia
- Sarah Levine
- Joe Magliano
- *Crystal Maglio
- Michael Manderino
- Stacy Marple
- Katie McCarthy
- *Katie McIntyre
- *Courtney Milligan
- Jim Pellegrino
- Jackie Popp
- Josh Radinsky
- *Jenny Sarna
- Cynthia Shanahan
- *Jen Stites
- Mary Pat Sullivan
- Taffy Raphael
- Ursula Sexton
- *Rebecca Sela
- Teresa Soto
- Jennifer Wiley
- Mariya Yukhemenko

And many unnamed members of the Teacher Inquiry Networks

* Partnering classroom teachers

Project READI Science Design Team

California

- Cynthia Greenleaf
- Will Brown
- Gina Hale
- Ursula Sexton
- Irisa Charney-Sirott
- California Science Teachers
 - Adriana Jaureguy
 - Joanne Zachariades
 - Carolyn Aguirre

Chicago

- Mo-Lin Ko
- Katie James
- MariAnne George
- Susan Goldman
- Megan Hughes
- Carlos Rodriguez
- Chicago Science Teachers
 - Mike Fumigalli
 - Roberta Ingram
 - Katie McIntyre
 - Rachel Letizia

Project READI: Key Contributors to Efficacy Study in Biology

- Ashley Ballard
- Dylan Blaum
- Michael Bolz
- M Anne Britt
- Willard Brown
- Candice Burkett
- Irisa Charney-Sirott
- Gayle Cribb
- Angela Fortune
- Dawn Garrett
- MariAnne George
- Susan Goldman
- Cynthia Greenleaf
- Thomas Griffin
- Peter Hastings
- Katie James
- Monica Ko
- Kim Lawless
- Stacy Marple
- Jim Pellegrino
- Jackie Popp
- Carlos Salas
- Brent Steffens
- Patricia Wallace
- Mariya Yukhemenko

***About 2400 students and their teachers in and around Chicago.**

Today's Talk

- Observational Study
- Iterative Design-Based Research in Teacher Inquiry Networks
 - Teacher Learning Processes and Models
 - Instructional Modules
 - Implementation and Refinement
- Efficacy Study: Randomized Controlled Trial
 - Refined Modules and Resources
 - Learning Progression
 - Refined Teacher Learning Model/Sequence
 - Design and outcomes

Making the Road by Walking



A Confluence of Many Streams



First Steps

Existential Description

"What's going on out there in the real world of classrooms?" (Pearson & Gallagher, 1983)

Data Corpus

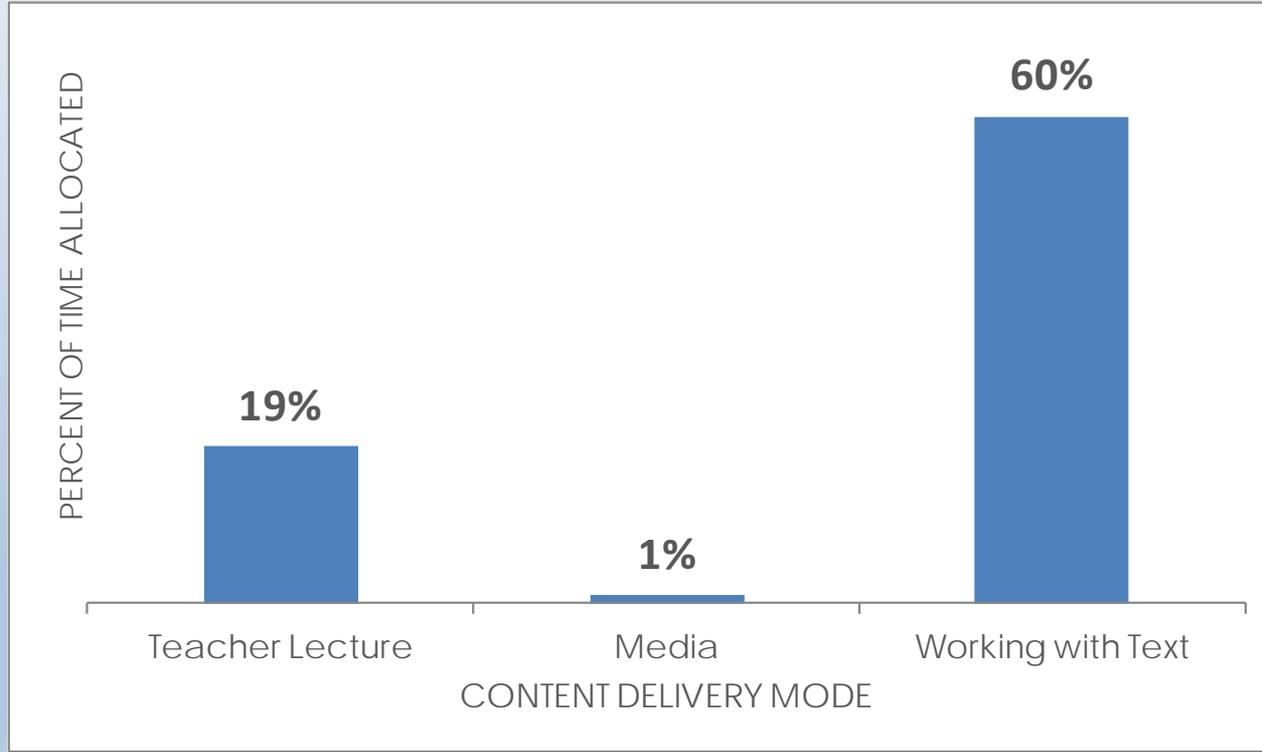
- 71 lessons from diverse settings in the greater Chicago and San Francisco Bay areas
- English language arts, history, and science, grades 6-12
- Teacher selection based on reputations for good instructional practice and student engagement
- Observed prior to any intervention
- Asked to see “typical lesson in which reading and discussion play a central role”
- Videotapes focused on teacher talk and behavior

Video Analysis Coding Scheme

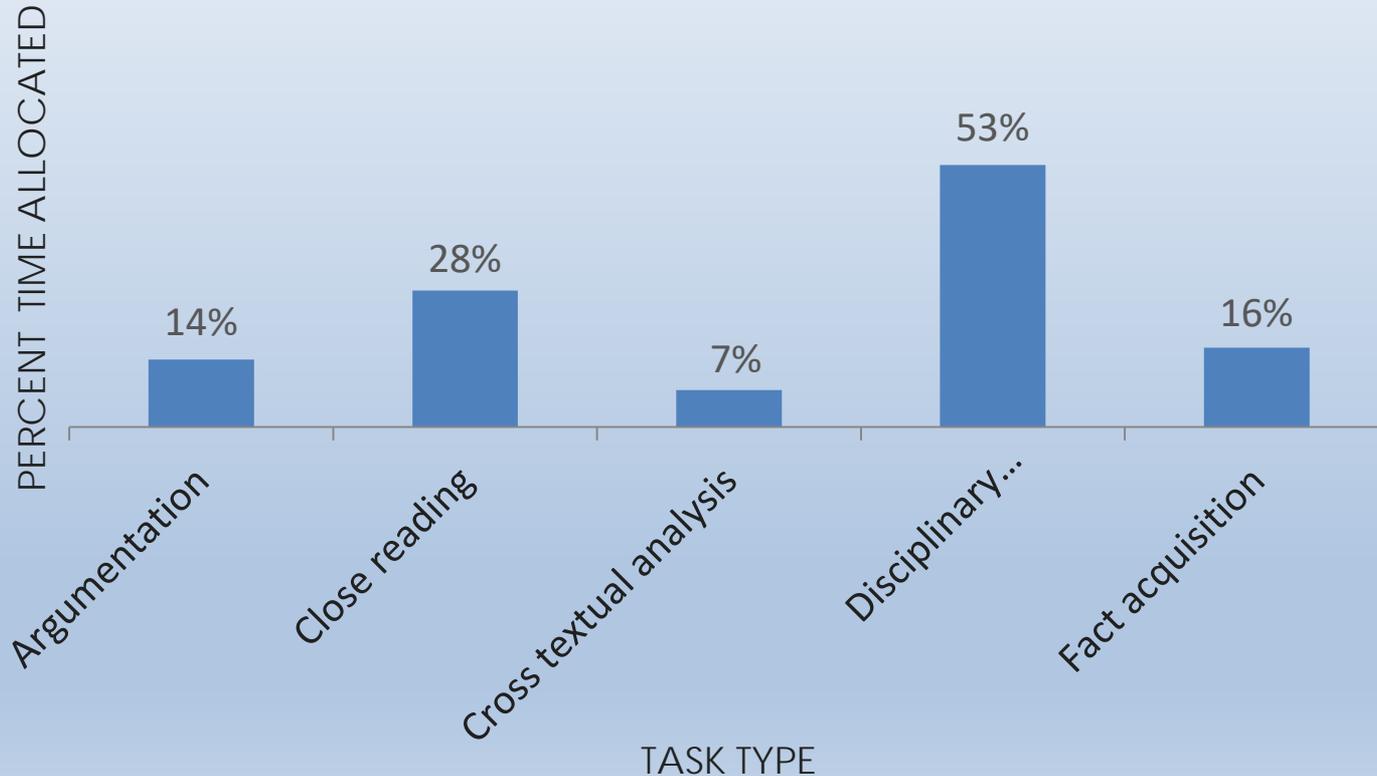
Opportunity to learn as measured by length of exposure during lessons for:

1. Text-based learning
2. Close reading
3. Cross-textual analysis
4. Evidence-based argumentation
5. Disciplinary knowledge-building

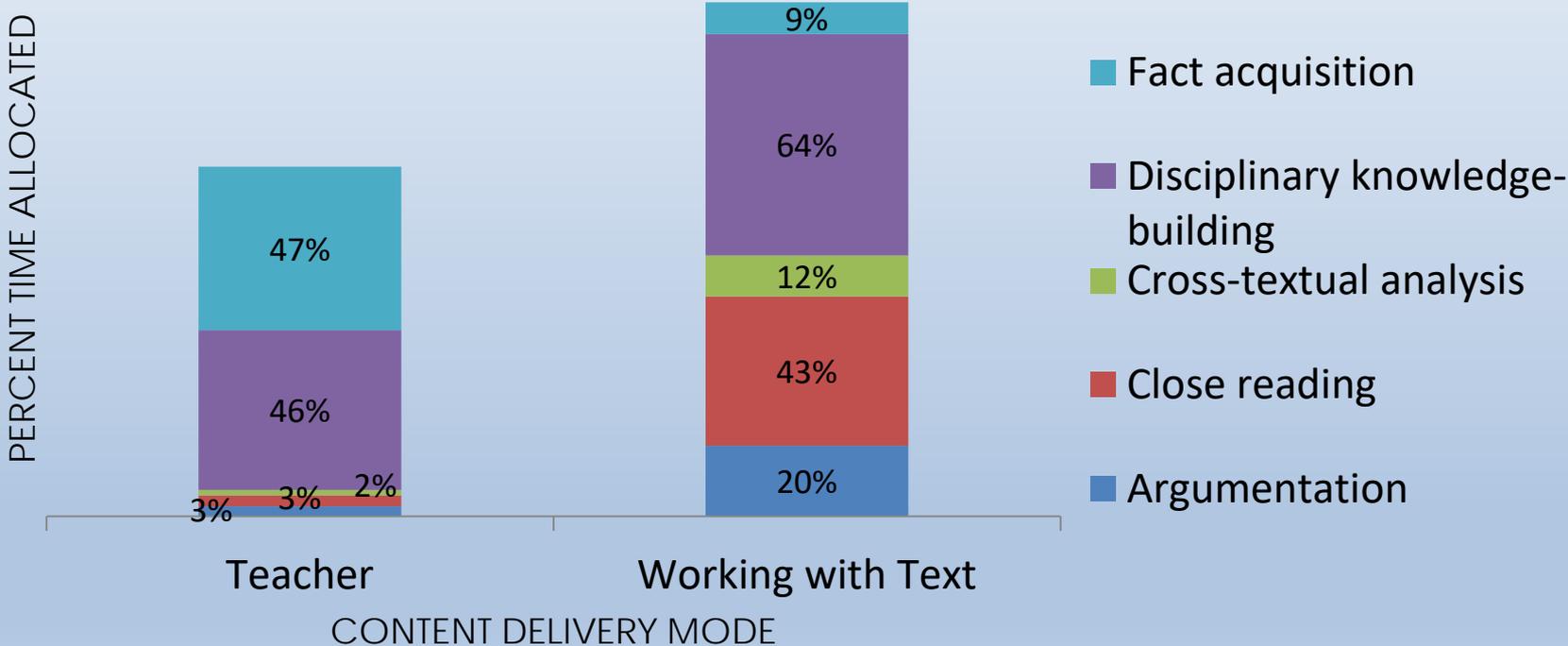
Teachers allocated three times more class time to working with text than to lecture



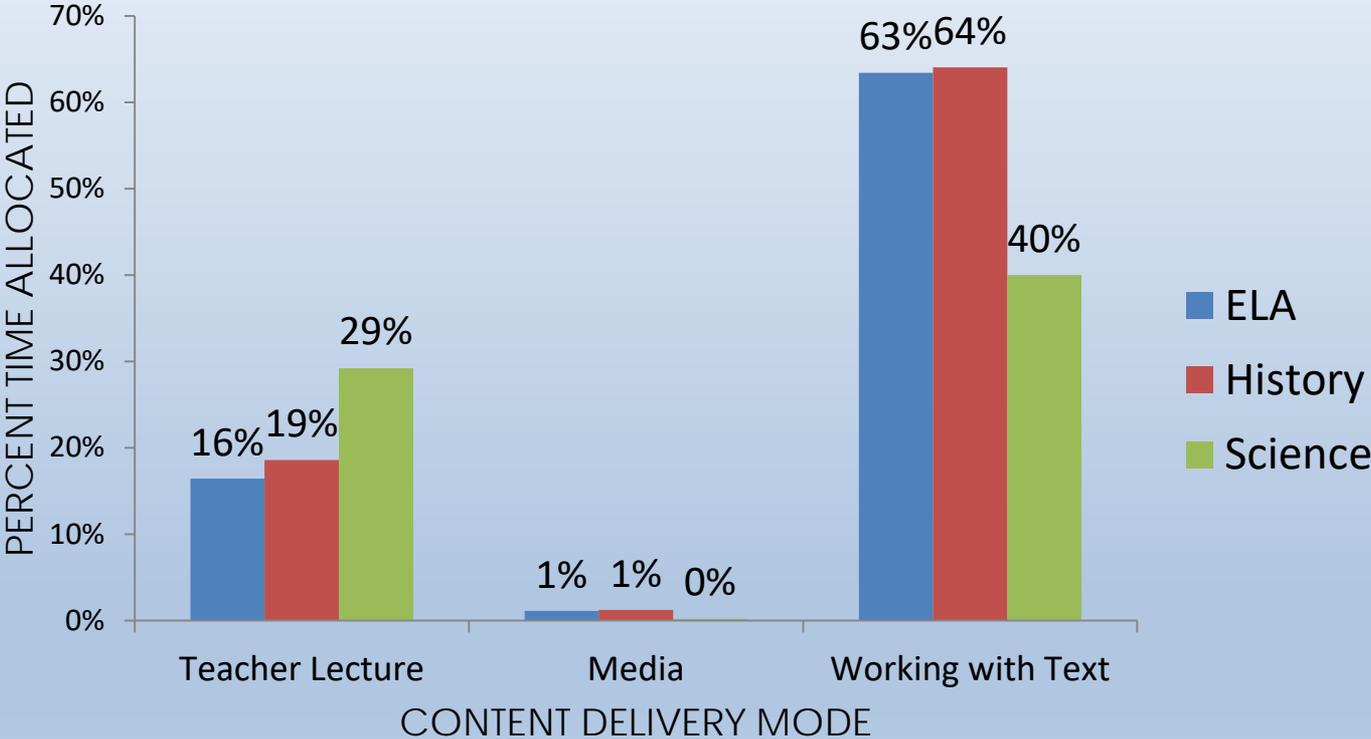
Students had little opportunity to engage in elements of text-based argumentation from multiple sources



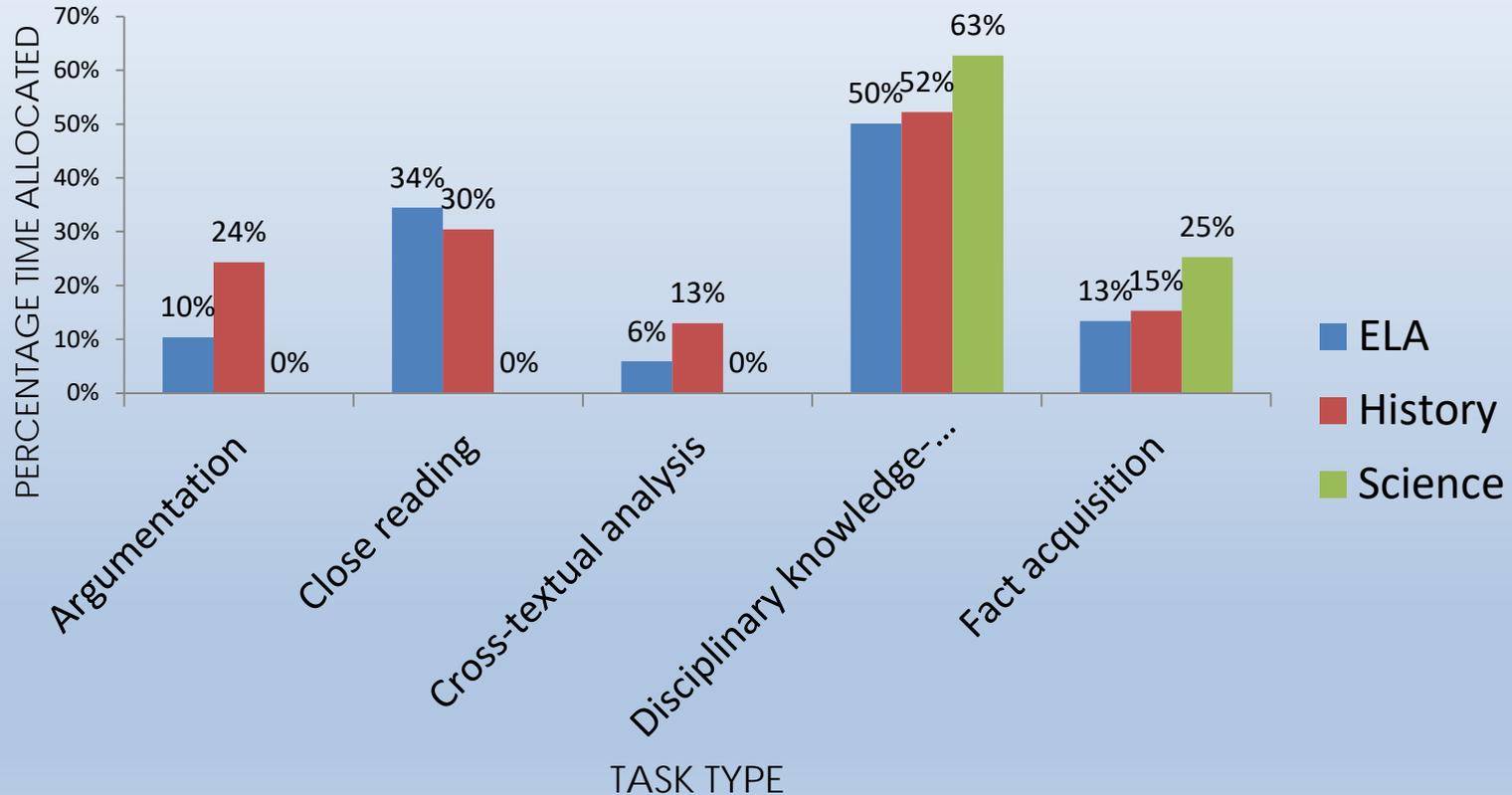
Working with text was associated with a greater variety of tasks than teacher lecture



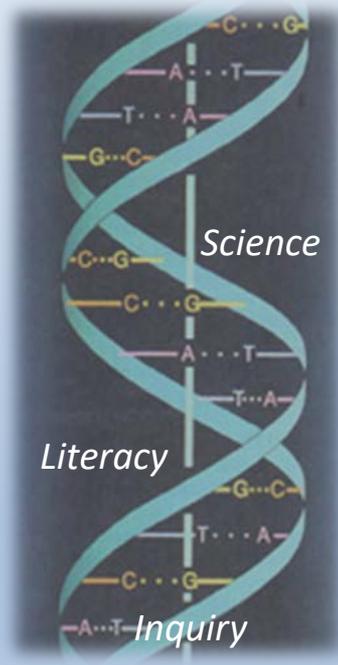
Science teachers allocated more time to lecture and less time to working with text compared with ELA and history/social studies teachers



No science lesson incorporated any argumentation, close reading, or cross-textual analysis



Challenge: Reading Science *as Doing and Learning Science*



Goal: to *simultaneously* develop students'

- science knowledge
- interest and engagement in science learning
- participation in science inquiry practices
- ability to make meaning of science texts for scientific purposes
- reading for understanding in science

PROJECT **READi**

Reading, Evidence, and Argumentation in Disciplinary Instruction

Reading for Understanding in Science

the capacity to use evidence
from multiple information sources
to construct, justify, and critique
models/explanations
of science phenomena

Why Should Argumentation Play a Vital Role in Learning Science?

"To ask of other human beings that they accept and memorize what the science teacher says, without any concern for the meaning and justification of what is said, is to treat those human beings with disrespect and is to show insufficient care for their welfare.

..students ... have a right to expect from their teachers reasons for what the teachers wish them to believe.

..possessing beliefs that one is unable to justify is poor currency when one needs beliefs that can reliably guide action."

Norris, S. P. (1997). Intellectual Independence for Nonscientists and Other Content-Transcendent Goals of Science Education. *Science Education*, 81(2), 239-58 (p. 252).

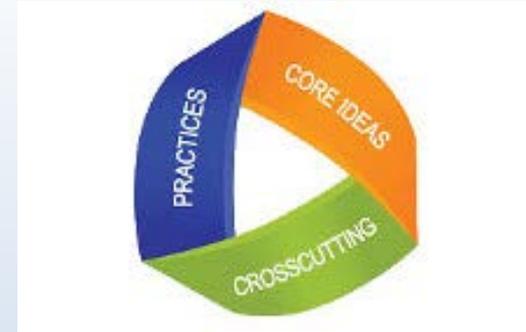
Building Knowledge through Argumentation in Science

“The great thing about science is that there are these hypotheses and tremendous arguments about what is the case. We’ll have one idea and then someone will say, ‘Not so fast! There’s another way this could have come about.’”

David R. Lindberg, Professor of Integrative Biology, University of
California Berkeley

East Bay Science Café, March 7, 2012

Next Generation Science Standards



Science and Engineering Practices –

Practices scientists use to investigate and build models and theories about the natural world

Practices engineers engage use to identify problems and design and test solutions

Crosscutting Concepts –

Generalizable concepts with broad applicability across science domains

Disciplinary Core Ideas –

Ideas with broad importance across multiple science and engineering domains

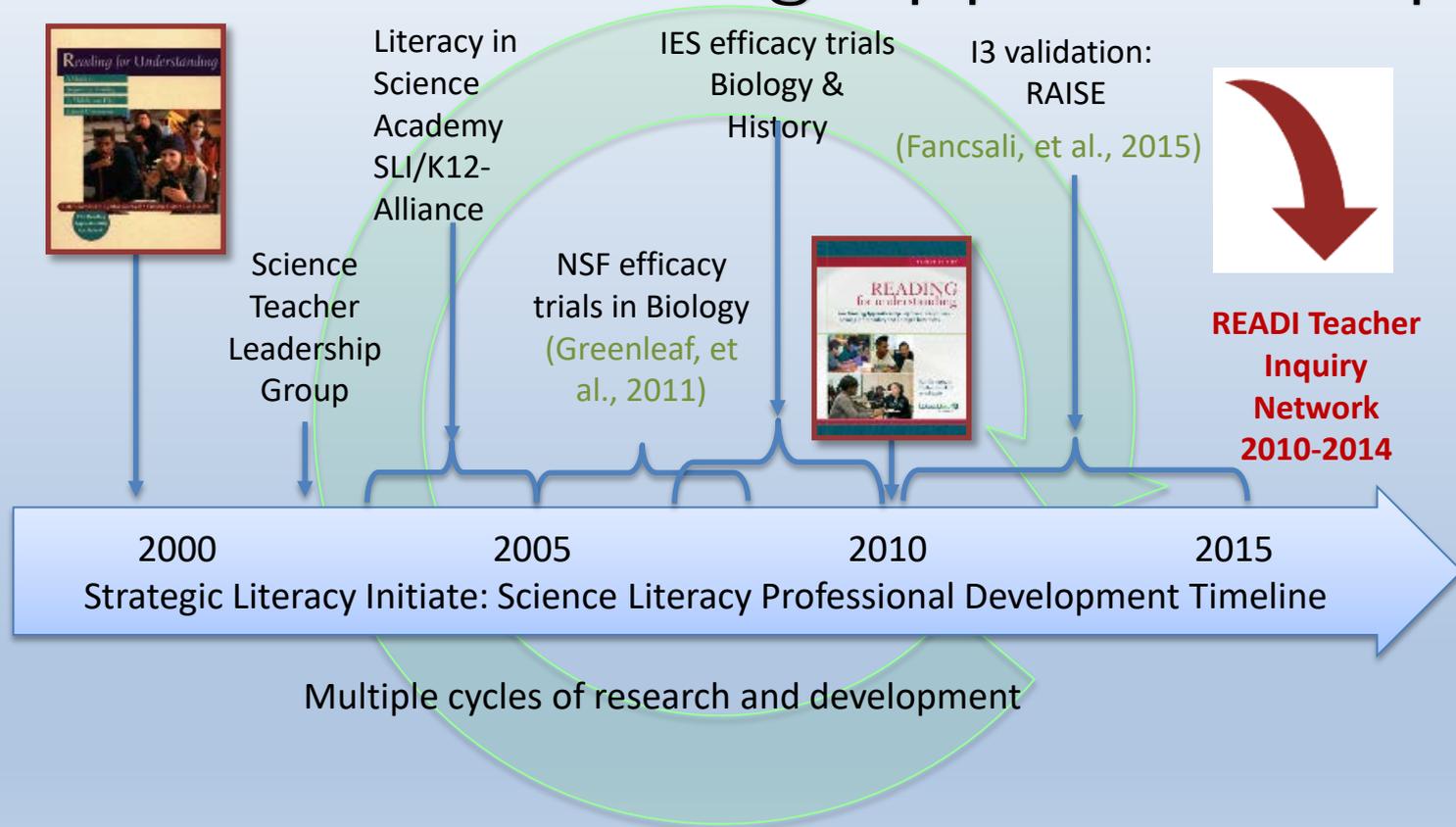
Key organizing concepts within or across science domains

Next Steps: Iterative Design-Based Research in Teacher Inquiry Networks

We convened teacher inquiry networks to co-design:

- Text-Based Investigation Modules
- Learning progressions advancing literacy and inquiry practices
- Assessment tools
- Ongoing professional learning for teachers

Model of Teacher Learning Builds Upon Prior R&D in Reading Apprenticeship



Collaborative Design: Teacher Inquiry Network

- Surface knowledge implicit in teachers' science discourse and literacy practices
- Develop Instructional Scaffolds and Tools based on these understandings
- Design and implement Text-based Investigations individually and collaboratively
- Carry out iterative cycles of implementation, analysis and revision



Tapping and building teacher expertise



Inquiry Approach: Noticing and Handling Comprehension Roadblocks

Methanotrophic bacteria occupy benthic microbial mats in shallow marine hydrocarbon seeps, Coal Oil Point, California

Haibing Ding

Department of Earth Science and Marine Science Institute, University of California, Santa Barbara, California, USA

Benthic makes me think of riverbeds or river banks

David L. Valentine

Department of Earth Science and Marine Science Institute, University of California, Santa Barbara, California, USA

Microbial mats composed of giant sulfur bacteria are observed throughout the benthos along continental margins. These communities serve to oxidize dissolved sulfides to sulfate, and are typically associated with the recent exposure of sulfide-rich sediments. Such mats are also ubiquitous in areas of hydrocarbon seepage, where they are thought to consume sulfide generated in underlying sediment. Despite the high abundance of dissolved methane in hydrocarbon seeps, few studies have considered the importance of methanotrophy in mat

Word Detective

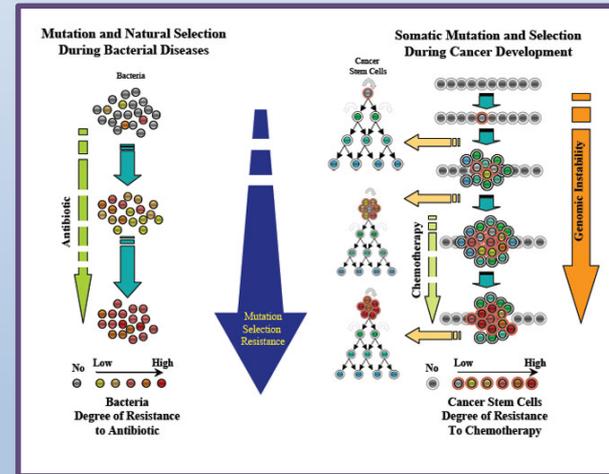
Reread the text and try to make sense of the survival words. For each word, make notes about the strategies you used to clarify it. Also, describe what each survival word means in this context

| Word | Word-Learning Strategy | Meaning in this Context |
|---------------------|---|--|
| Benthos, benthic | Re-read around word, noted marine, continental margin, sediment, microbes Asked where are all these? | Located at bottom of ocean - maybe the sediment or the organisms |

- May not be cognizant of the literacy demands of Science (Heller & Greenleaf, 2007; Pearson, Moje & Greenleaf, 2010)
- Need to learn to see past their “expert blind spots” (Braunger, et al., 2006; Nathan & Petrosino, 2003)
- Are largely unaware of their own specialized literacy expertise (Greenleaf & Schoenbach, 2004)

Constructing Models Inquiry

“Make a list of ideas you know, remember or wonder about science models.”



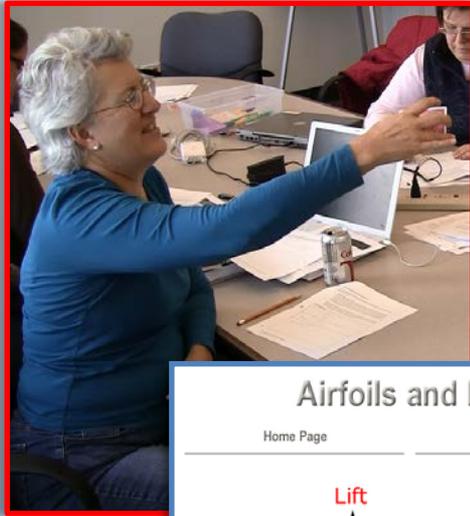
Science Practices and Processes

Findings:

- Teachers held multiple conceptions of “model” – **surrogate, analogy, demonstration, representation, “the accepted understanding”**
- Teachers valued concept attainment
- Teachers were not sure why they should engage students in constructing **causal models** of their own



Falling Cards Inquiry: Teachers Construct and Critique Explanatory Models



BRAIN FOOD

**It's a Bird! It's a Plane!
It's Bernoulli's Principle!**

The most common commercial airplane in the skies today is the Boeing 737 jet. A 737 jet is almost 37 m long and has a wingspan of 33 m. Even without passengers, the plane weighs 350,000 N. That's more than 35 times heavier than an average car! How can something so big and heavy get off the ground, much less fly 10,000 m into the sky? Wing shape plays a role in helping these big planes—as well as smaller planes and even birds—achieve flight, as shown in **Figure 15**.

According to Bernoulli's principle, the faster-moving air above the wing exerts less pressure than the slower-moving air below the wing. The increased pressure that results below the wing exerts an upward force. This upward force, known as lift, pushes the wings (and the rest of the airplane or bird) upward against the downward pull of gravity.

Figure 15 Wing Shape Creates Differences in Air Speed

The curved tip of the wing causes the air passing above the wing to travel a longer distance than the air moving below the wing.

The air above the wing moves faster than the air below the wing.

How do we develop explanatory models?
How does this help us engage students in constructing models?

Airfoils and Lift

Home Page Theory Index

An airfoil is a device which gets a useful reaction from air moving over its surface. When an airfoil is moved through the air, it is capable of producing lift. Wings, horizontal tail surfaces, vertical tails surfaces, and propellers are all examples of airfoils.

Bernoulli or Newton's Laws for Lift?

Which is best for describing how aircraft get the needed lift to fly? Bernoulli's equation or Newton's laws and conservation of momentum? This has been an extremely active debate among those who love flying and are involved in the field. If the question is "Which is physically correct?" then the answer is clear -- both are correct. Both are based on valid principles of physics. The **Bernoulli equation** is simply a statement of the principle of **conservation of energy** in fluids. **Conservation of momentum** and **Newton's 3rd law** are equally valid as foundation principles of nature - we do not see them violated. This physical validity will undoubtedly not quell the debate, and this treatment will not settle it. But perhaps it can at least indicate the lines of the discussion.

Effective bound vortex

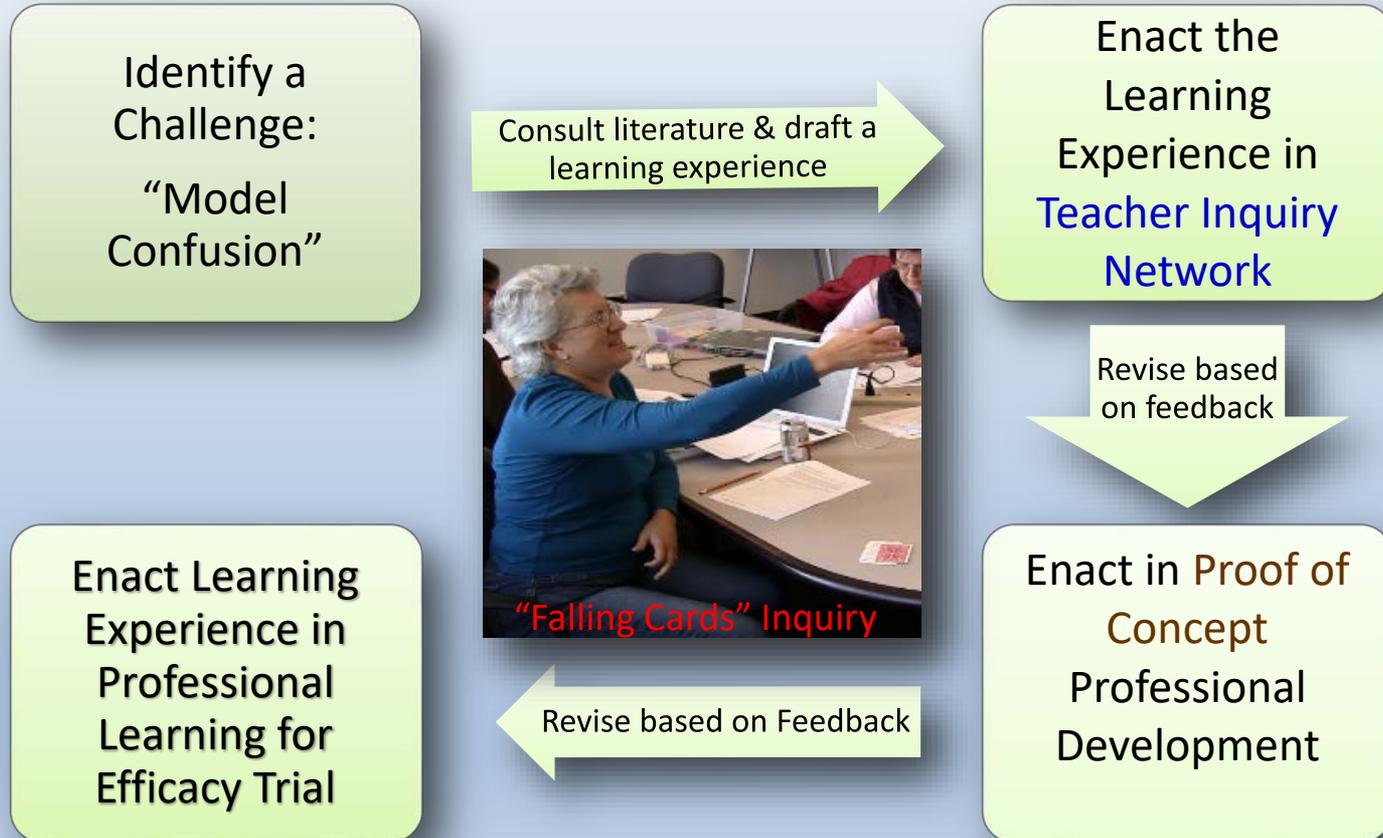
Observed downwash encourages a view in terms of Newton's 3rd Law and conservation of momentum.

Shed vortex

Fascinating vortex phenomena encourage a view in terms of the Kutta-Joukowski theorem.

“The study of how educational interventions work can never be far removed from the task of engineering them to work better.”

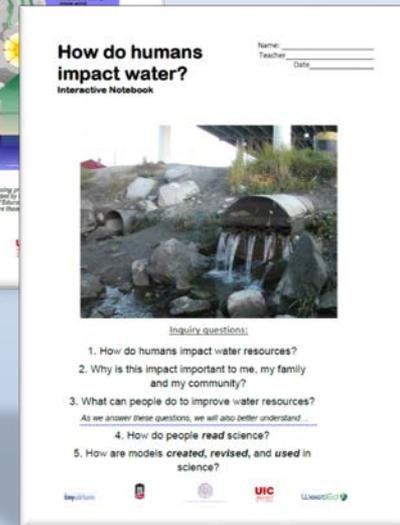
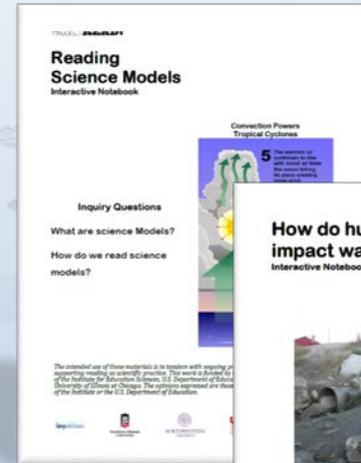
(Newman, Griffin, & Cole, 1989, p. 147)



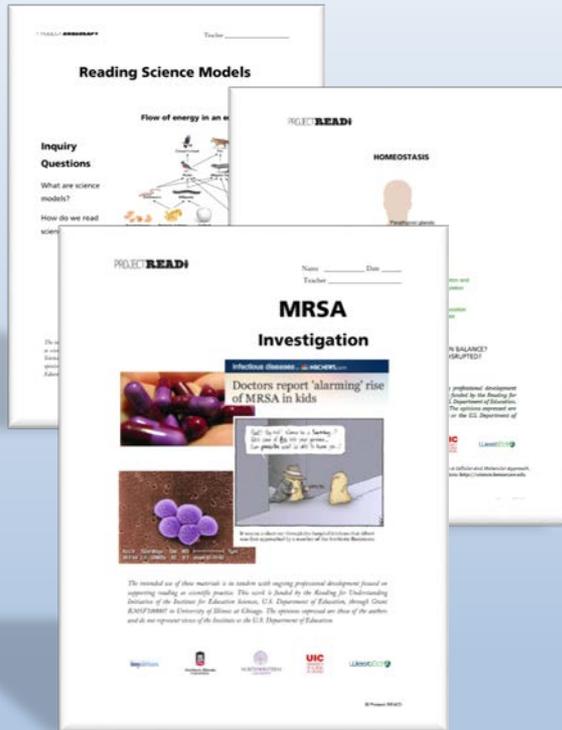
Simultaneous Steps: Designing Text-Based Investigation Modules

Middle School

- Human Impact on Water Resources module and Human Impact on Carbon Cycle Pre/Post Assessment – Earth Science
- Reading Models Mini-Unit
- MRSA Module and Pesticide-Resistant Head Lice Pre/post assessment –Life Science
- Teacher developed modules



Text-Based Investigation Modules



High School

- Methicillin Resistant Staph Aureus module and Malaria Pre/post assessment –Life Science
- Reading Models Mini-Unit, Life Science
- Homeostasis – Life Science
- Cell Theory Text Set – Life
- Teacher developed modules

Design Principles for Text-Based Investigations

1. Investigations are **built around science phenomena** (Berland & Reiser, 2009; Latour & Woolgar, 1986)
2. Text sets **offer a range of science representations** sequenced to support investigations into phenomena (van den Broek, 2010)
3. Consequential **tasks** are science practices **requiring reading to develop explanatory models and argumentation** (Cavagnetto, 2010; Ryu & Sandoval, 2012; Windschitl, Thompson, & Braaten, 2008)
4. Instructional supports foster **reading for inquiry purposes** (Schoenbach, Greenleaf & Murphy, 2012)
5. Instructional supports to **develop and evaluate causal explanations** for phenomena (Chin & Osborne, 2010; Passmore & Svoboda, 2012)
6. **Discourse rich pedagogies** support knowledge building and evidence-based argumentation (Von Aufschnaiter, Erduran, Osborne & Simon, 2008)

7. Teacher mediation supports and orchestrates students' reading, modeling, and argumentation practice (Gibbons, 2003; McNeill & Krajcik, 2008)

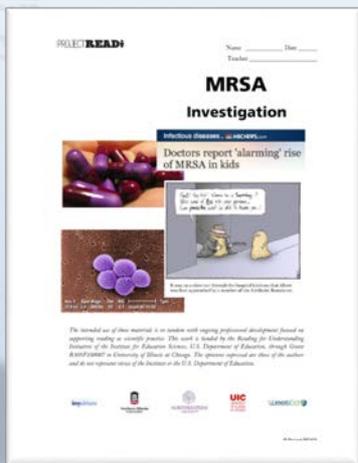


Teachers mediate students' opportunities to learn

READI Science Student Learning Goals

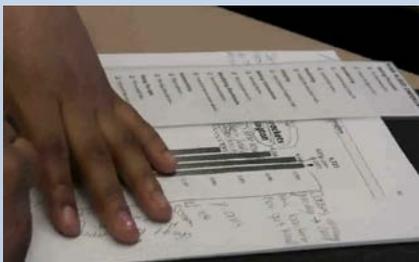
| | |
|---|---|
| 1 | Engage in close reading of a range of science representations; Identify, analyze and interpret scientific evidence in texts/sources including graphs, diagrams, models, exposition |
| 2 | Synthesize evidence and information across multiple sources including graphs, diagrams, models, exposition |
| 3 | Construct, justify, and critique explanations and explanatory models of science phenomena from scientific evidence drawn from multiple sources and using science principles, frameworks, and enduring understandings |
| 4 | |
| 5 | |
| 6 | Demonstrate understanding of the epistemology of science through inquiry dispositions and conceptual change awareness/orientation; generate inquiry questions, monitor their changing conceptions through multiple encounters with text, tolerate ambiguity, seek “best understandings giving the evidence.” |

Studying Implementation



Text-Based Investigations
with texts, tasks, and interactions mediated by
science teachers

Students' opportunity to learn to read science
to develop explanatory models of science
phenomena



Students' reading for understanding in science

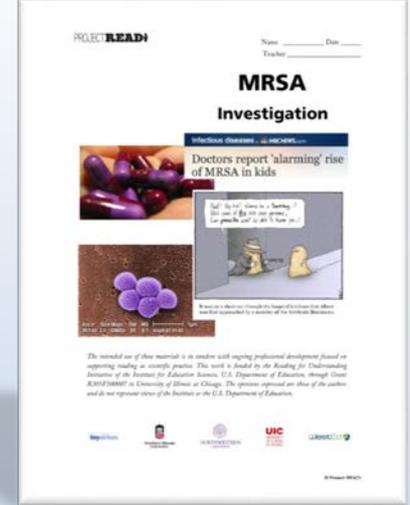
Context

MRSA Implementation Study

- Participants
 - Ms. J, high school life science teacher
 - Title 1 high school serving diverse population: 35% African-American, 32% Hispanic, 19% Asian, 8% Caucasian; 73% FRPL; 12% EL
 - 11th grade physiology - least intensive class satisfying graduation requirement
- Prior observations and interviews
 - Reliance on lecture, PowerPoint presentations, and demonstrations to deliver science content
 - Assignment of reading and annotation (annotation familiar to students)
- MRSA Text-Based Investigation
 - Late spring implementation, 20 lessons (4+ weeks)
 - Assessments administered just prior to and at the end of MRSA unit

MRSA Investigation

- The emergence of methicillin resistant *Staphylococcus Aureus* requires an understanding of natural selection, adaptation of species, and human impact on micro-evolution
- Adolescents are at increased risk for contracting MRSA
- Safety precludes hands-on investigation of MRSA
- Text set: 14 texts, 2 videos from a range of reliable sources; multimodal representations
- Tasks: multiple opportunities to read, gather evidence, piece together explanatory models, and argue about their models
 - Infection
 - Spread
 - Evolution



Study Questions

- How was time allocated to various kinds of learning tasks for science reading, knowledge building, and investigation?
- How did the teacher's practices mediate student learning?
- How did instruction in the TBI unit influence students' science reading?

Data Sources

- Student Pre/Post Assessments
 - Annotation on texts
 - Explanatory models
- Classroom Observations: Video Segmentation and Analysis of Teacher Practices
 - Field notes
 - Video and audiotaping
 - Teacher debriefs

Pre-Post Reading and Modeling Task: Malaria

Introduction

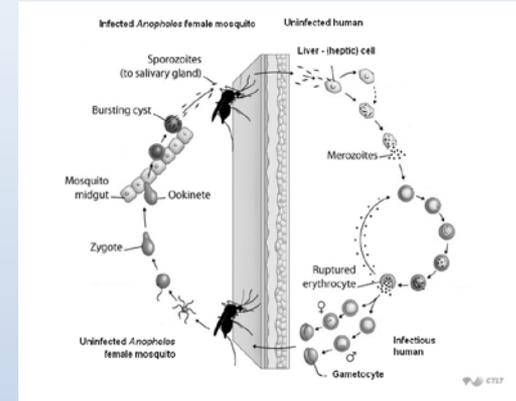
Malaria is a serious disease in many parts of the world. It has many “causes” linked in a chain of events. Scientists try to prevent the disease by breaking links in the chain.

Task

Read the texts on the following pages and **make notes in the margins** about your reading, thinking and problem solving processes.

After you have read the texts, respond to the following, using information from your reading:

- Use the information in the texts to **create a model, using visuals and words, that explains how malaria could cause millions of deaths each year in Africa**. (You may add to the model in text 4, but yours may also look different).
- Based on what you know now, **explain what might be done at different points to stop the transmission of malaria** and use evidence from your reading to explain why these might work.



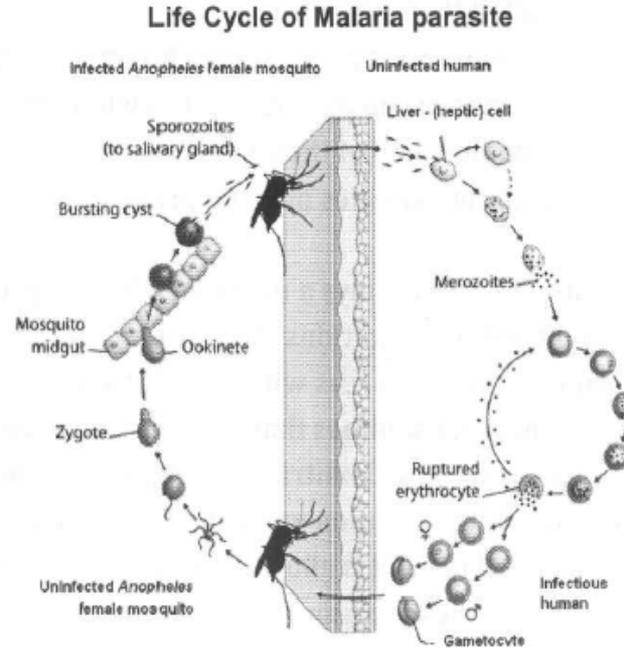
TEXT TWO

How is malaria spread?

Malaria is caused by *Plasmodium* bacterium. These parasites infect successively two different hosts: humans and female *Anopheles* mosquitoes.

The parasites are transmitted to people who are bitten by infected female *Anopheles* mosquitoes. In humans, *Plasmodium* multiplies in the liver and then invades the red blood cells. Successive generations of parasites grow inside the red cells and destroy them,

releasing daughter parasites that continue the cycle by invading other red blood cells. These blood-stage parasites, called "gametocytes" (G. gamete + kytos, cell) cause the symptoms of malaria, which begin 6-10 days after infection.



cause of malaria

how malaria spreads



TEXT TWO

How is malaria spread? - moves from person to person singular for bacteria

Malaria is caused by Plasmodium bacterium. These parasites infect successively two different hosts: humans and female Anopheles mosquitoes.

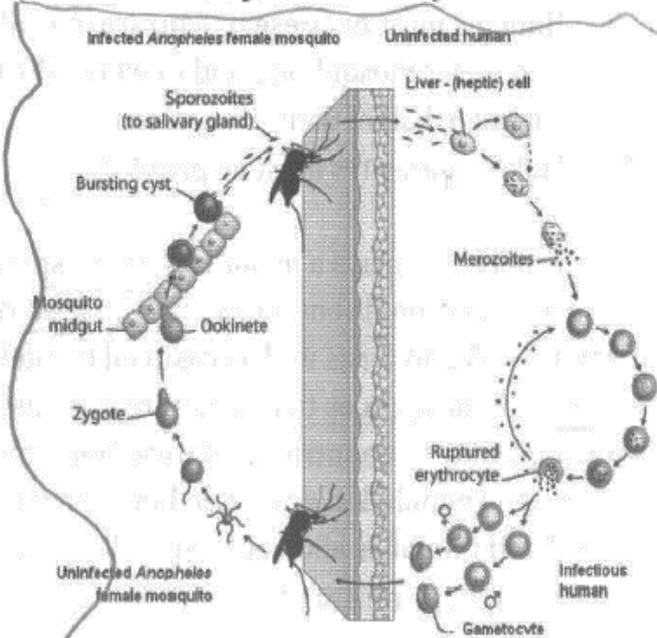
Host carry parasites or disease and allow them to live

The parasites are transmitted to people who are bitten by infected female Anopheles mosquitoes.

In humans, Plasmodium multiplies in the liver and then invades the red blood cells. Successive generations of parasites grow inside the red cells and destroy them,

fever, pain vomiting etc

Life Cycle of Malaria parasite



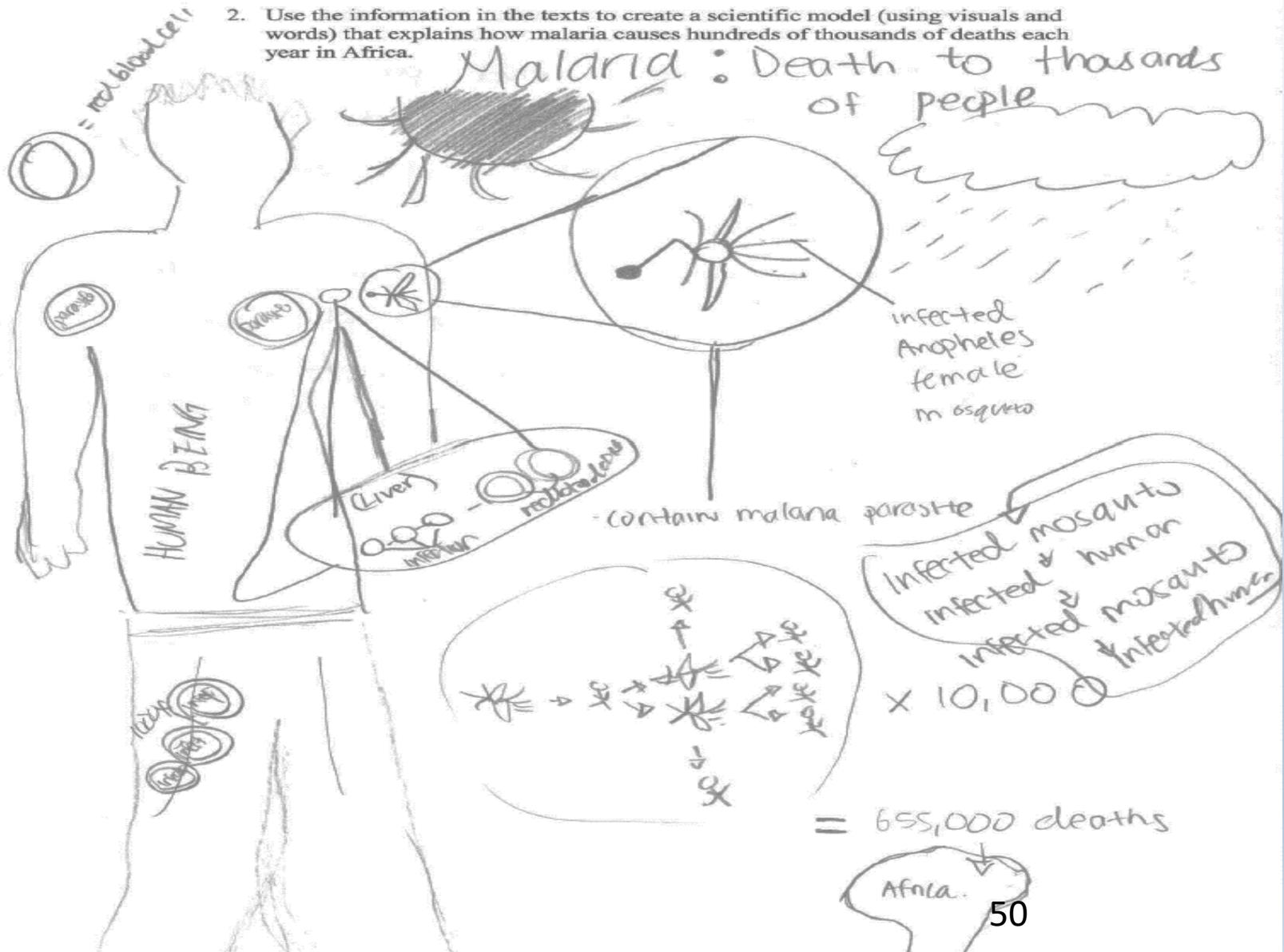
Once disease is successful in the blood of host, it grows in the blood cells/liver

releasing daughter parasites that continue the cycle by invading other red blood cells. These blood-stage parasites, called "gametocytes" (G. gamete + kytos, cell) cause the symptoms of malaria, which begin 6-10 days after

cause effect



2. Use the information in the texts to create a scientific model (using visuals and words) that explains how malaria causes hundreds of thousands of deaths each year in Africa.

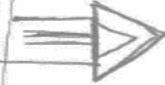


2. Use the information in the texts to create a scientific model (using visuals and words) that explains how malaria causes hundreds of thousands of deaths each year in Africa.

Malaria and its EFFECTS

Ingredients

- humans - 
 - Female Anopheles 
 - Malana parasite 
 - Warm climate 
 - wet areas 
- must all be in contact



Plasmodium berterium

INJECTS

Africa is very warm and has access to water

Female Anopheles mosquito

(IDEAL PLACE for Malana)



10-18 days pass
during this time the parasite develops infectious stage and reproduces

INFECTED Female Anopheles



The Malana disease is now in both mosquito and humans. The mosquito can now infect more humans. The humans can also spread the disease to other mosquitos.

This infection is moved quickly, transmission is quick but it is difficult to cure.

THIS CYCLE CONTINUES.

THIS PROCESS IS **Bigger** with more spreading.

216 million cases of malarina

655,000 deaths → In humans, the disease infects the liver and blood.



Text-Based Investigation Assessment Annotation Codes

- Marks & comments
- On verbal or visual texts
- Voice (student vs. verbatim from text)
- Reading process (e.g. questioning, making inferences, making connections)
- Science reading process (e.g. attending to science, phenomenon, elements and interactions relevant to model generation)

Draws on **process tracing studies** (Afflerbach, 2000; Afflerbach & Cho, 2009; Ericsson & Simon, 1993, 1980; Paris & Flukes, 2005; Pressley & Afflerbach, 1995) and prior work to develop and test **Integrated Learning Assessment** (Silver et al., 2011).

Malaria Assessment Model Rubric

| Elements | 1 | 2 | 3 | 4 |
|------------------|--------------------------------|--|--|---|
| A. Humans (H) | Inclusion of human in model | Humans can exist in <u>EITHER</u> infected or uninfected | Humans can exist in <u>BOTH</u> uninfected and infected by malaria | Level 3 <u>AND</u> describes 2 or more stages/process of malaria propagation inside the humans |
| B. Mosquitos (M) | Inclusion of mosquito in model | Mosquito can exist in <u>EITHER</u> infected or uninfected | Mosquito can exist in <u>BOTH</u> uninfected and infected by malaria | Level 3 <u>AND</u> describes 2 or more stages/process of malaria propagation inside mosquitos (<i>i.e.</i> zygotes, cyst, sporozoites) |

Malaria Assessment Model Rubric

| Interactions | 1 | 2 | 3 | 4 |
|--|--|----------------------------------|---|--|
| A. Movement of plasmodium through mosquito feeding on human blood | No mention of infection and disease as stages or how it moves from host to host. <i>NO identification of plasmodium as 3rd species</i> | Evidence of ONE-WAY transmission | Evidence of BI-DIRECTIONAL transfer of plasmodium | BI-DIRECTIONAL movement and clear description of the parasite moving between the organisms |
| B. Continuity & transmission of plasmodium (<i>directionality</i>) | No mention of H → M or M → H spread | Either mention of H → M or M → H | Both H → M <u>and</u> M → H | Discusses H → M and M → H as continuous cycle |

Malaria Assessment Model Rubric

| Aggregate Effects | 1 | 2 | 3 |
|-----------------------------------|---------------------------------------|---|---|
| Aggregate level impact of malaria | No mention of aggregate level outcome | Discusses the large-scale impact by going beyond the human \leftrightarrow mosquito relationship, but <u>does not clearly or accurately</u> delineate how human \leftrightarrow mosquito <i>leads to</i> large scale impact | Integrated description of how human \leftrightarrow mosquito interactions leads to aggregate level impact on large population. This must include: <ol style="list-style-type: none"> 1. many mosquitos and individuals have malaria 2. one single mosquito can infect multiple individuals 3. multiple individuals can transfer plasmodium to many mosquitos |

Findings: Changes in Students' Science Reading and Modeling

11th Grade Physiology

| Students (n = 26) | Average Pre | Average Post | Average Change |
|------------------------------------|----------------|-----------------|-------------------|
| Comments | 3.7 | 9.2 | 5.5** |
| Comments in Student Voice | 2.4 | 8.8 | 6.4*** |
| Close Reading Processes | 2.5 | 6.8 | 4.4** |
| Making Predictions / Inferences | 0.3 | 1.5 | 1.1* |
| Questioning | 0.2 | 2.4 | 2.2*** |
| Science Close Reading Processes | 2.3 | 6.2 | 3.9** |
| Model Summary Score (0-16) | 5.1 | 6.9 | 1.8* |
| Model Elements Score (0-6) | 2.6 | 3.3 | 0.7~ |
| Model Interactions Score (0-6) | 2.2 | 3.0 | 0.8~ |

Opportunity to Learn as Measured by Length of Exposure During Lessons

Video Segmentation Codes

- Content Delivery:
 - Teacher
 - Working with Text
- Task:
 - Close Reading
 - Cross Textual Analysis
 - Argumentation
 - Disciplinary Knowledge Building
 - Fact Acquisition
- TBI Elements:
 - Inquiry Orientation
 - Modeling/Visual Representation
 - Text-Based Discussion
 - Word Learning
 - Metacognition
 - Discussion Routine

Disruption of Science Instruction as Usual

– Ms. J’s Implementation of MRSA

| Segment Code | Year 1 Science Classrooms N=9 | Ms. J’s MRSA Unit Implementation |
|--|-------------------------------|----------------------------------|
| Source of Science Content | | |
| Teacher <i>Teacher lecture, demonstration or PowerPoint. Teacher has done the work of understanding and organizing science material and delivers science information to students.</i> | 26% | 0% |
| Working with Text <i>Content made available through text(s). Text is defined broadly to include a wide range of materials, including graphs, manipulatives, exposition, maps, diagrams, etc.</i> | 42% | 94% |

Disruption of Science Instruction as Usual

– Ms. J’s Implementation of MRSA

| Segment Code | Year 1 Science Classrooms N=9 | Ms. J’s MRSA Unit Implementation |
|--|-------------------------------|----------------------------------|
| Opportunity to Learn | | |
| Close Reading <i>Task requires students to approach texts to understand them vs. to find information. Involves interactive negotiation of meaning.</i> | 0% | 53% |
| Cross Textual Analysis <i>Task/activity involves synthesis, evaluation, or critique of information from multiple texts.</i> | 0% | 38% |
| Argumentation <i>Task asks students to make a claim or assertion that is supported by evidence that connects to the claim in a principled way.</i> | 0% | 37% |
| Disciplinary Knowledge Focus <i>Task references overarching frameworks, concept and themes of the discipline.</i> | 60% | 70% |
| Fact Acquisition <i>Task focus is testing understanding, recall or rote learning with little or no opportunity for sensemaking.</i> | 25% | 0% |

Fostering Reading as Science Inquiry Practice

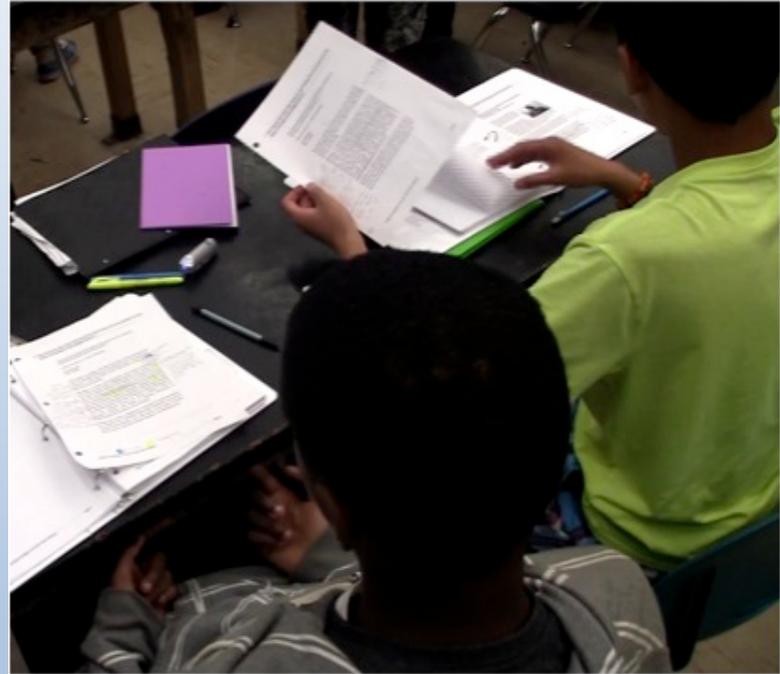
– Ms. J’s Implementation of MRSA

| Segment Code | Year 1 Science Classrooms N=9 | Ms. J’s MRSA Unit Implementation |
|--|-------------------------------|----------------------------------|
| Text-Based Investigation Elements | | |
| Inquiry Orientation <i>Task framed as inquiry to explain cause, significance, or prevention of MRSA infection</i> | NA | 53% |
| Modeling/Visual Representation <i>Task asks students to develop a visual representation describing a scientific process</i> | NA | 21% |
| Text-Based Discussion <i>Task requires students to use information from texts during discussion focused on understanding phenomenon</i> | NA | 14% |
| Word Learning <i>Task explicitly involves attention to science word learning and word learning strategies</i> | NA | 8% |
| Metacognition <i>Task explicitly models or requires students to articulate thinking, reasoning, or reading processes</i> | NA | 28% |
| Discussion Routine <i>Task explicitly focuses on how to carry out discussion with peers, including purposes and roles for the discussion</i> | NA | 35% |

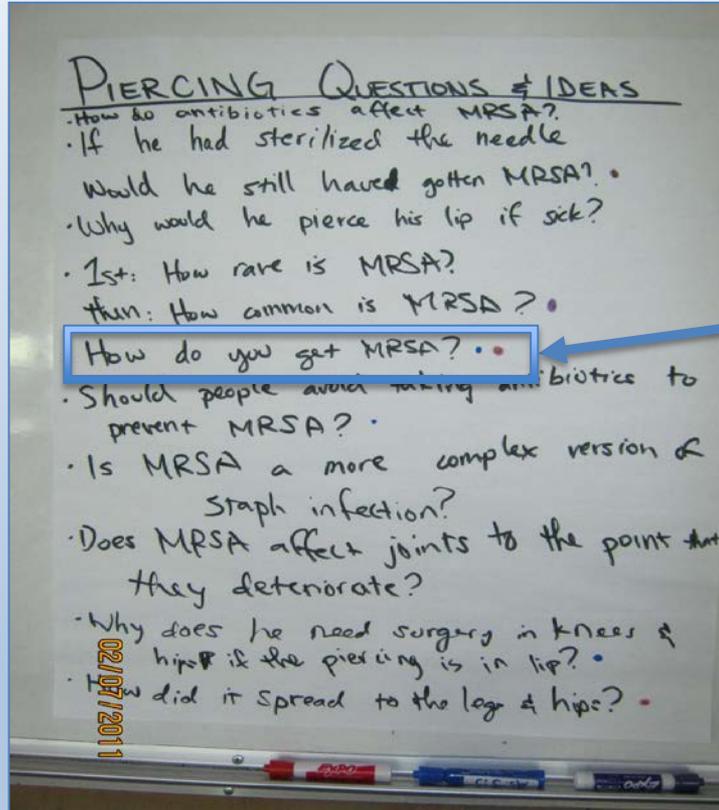
Snapshots of Instructional Practices Mediating MRSA Investigation



Re-socializing students to engage in close reading to generate inquiry questions and build knowledge



Fostering an Inquiry Stance



Initially students directed questions to the teacher as the source of knowledge

S1: I was going to ask you a question – How do you get MRSA?

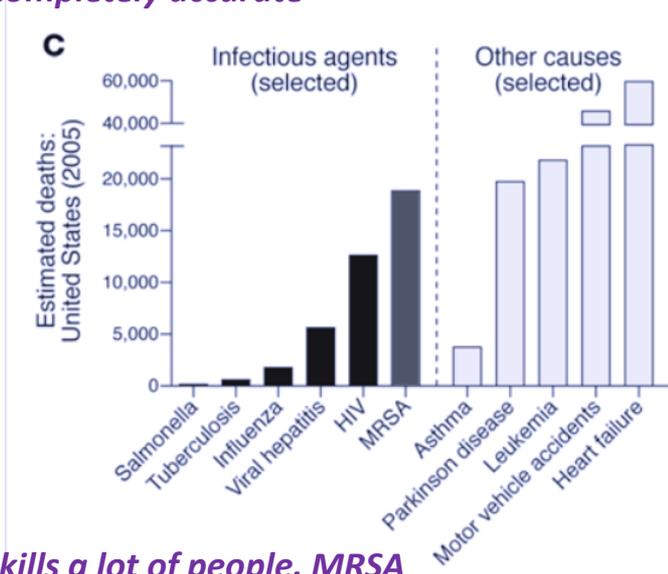
S2: She's asking you actually, not for the board.

Ms J: ..this unit is for you to learn how to manipulate the information so that you can solve the question yourself

Fostering Sense-Making with Science Representations

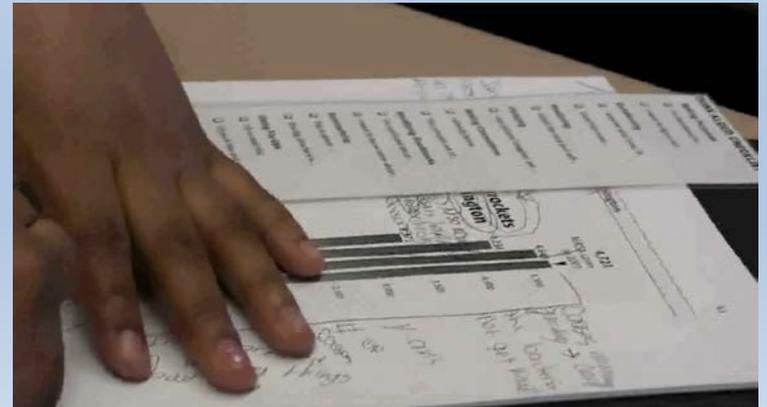
Comparison of Estimated Death in U.S. in 2005

The labels say 'estimated deaths in the United States.' I think this is an estimate so not completely accurate



Wow, HIV kills a lot of people. MRSA kills more people than HIV.

- **Teacher modeling** of reading and reasoning processes
- **Student thinking aloud** on another graph **with a partner**
- Use of routines and scaffolds: “You’ll take turns thinking aloud and **you’ll take turns documenting each other’s thinking**. I want you to **pay careful attention** to the sentence starters people are using **as they are reasoning things out**”



Fostering Scientific Argumentation: Pressing for Making Reasoning Explicit

S: The infection is resistant to antibiotics.

Ms. J: [pause while she writes on a T-chart under Evidence] **Why is this information helpful? We need to push your group.** Anyone in your group can speak up for this. Actually, anyone in the class is welcome to piggy back on each other's ideas.

Later..

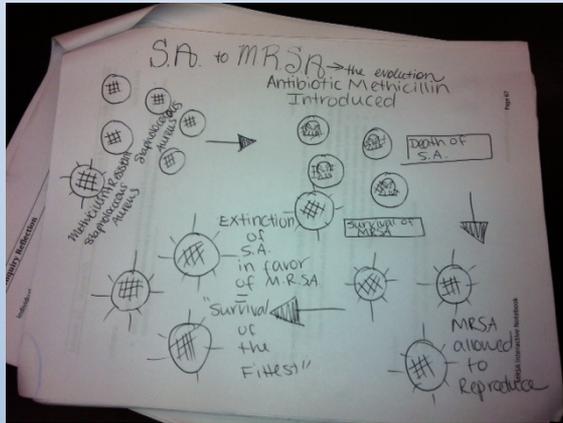
Ms. J: **How does knowing which antibiotics are going to work or which dosages are going to work help you size up the problem?** And let me please remind you the question is **“why should I care about MRSA?” Why should anyone care about MRSA?**

| <i>Evidence</i> | <i>Interpretation</i> |
|---|---|
| <i>Transmitted through cuts and bruises</i> | <i>Since people get cuts and bruises playing sport it is easier to get MRSA</i> |

S: **If** you need a certain antibiotic and you don't know exactly what it is, **it means** MRSA can spread very quickly and it is hard to cure. **So, that means** it is more important than other diseases that have antibiotics for them. **Because** its more deadly, more invasive.

Fostering Modeling as a Science Knowledge Building Practice

More conventional, text- and evidence-based, conceptual (thinking tool)



Ms. J's Written Reflections: Challenges in MRSA Implementation

- **Needing to break free from highly structured note taking** that simply regurgitates info and does not reflect and support connections and manipulation of text (ex: outlining)
- Developing structured roles to practice discussion stems and strategies and presentation of a complex idea
 - **Sometimes students find it difficult to articulate complex ideas** because they think it sounds too simple or silly.. **there is value in stating what seems obvious to them because their audience may not be making the same connections.**
- **Student modeling was initially artwork rather than a thinking and reasoning tool.**
 - I was surprised at how willing students were to make models, even though they **were worried about the appearance of their drawing.** Um, so they were a little more **fixated on their artwork in the beginning**, and then the deeper they got into it and realized like, Oh! These models are like for you, it's not so much to like, show off to the class.”

Lessons Learned

- TBI shows promise as “educative curriculum” both for science teachers and students
 - True **science inquiry emerged with text** as source material for investigations
 - Students learned science content, practices, and how read science texts
 - **TBI designs became a model for teachers to develop their own units** rooted in science literacy and argumentation goals
 - Ms. J developed TBI style unit investigating the effects of lifestyle and family history on the risk for developing diabetes

Lessons Learned

- The TBI unit **pressed on existing classroom routines and expectations.**
 - Practices not previously present in Ms. J's classroom began to emerge
 - **Students** were **not familiar with close reading or articulating their ideas in sense making discussions; teacher mediation and support necessary** to turn the work of sense making over to students
 - Ms. J **suggested a strategy of layering in socialization to new routines** in 1st semester, leading to extended TBI in 2nd semester
- Students initially treated **modeling as school display**, not as tentative representation of ideas to be iteratively refined as new evidence encountered
 - **More support for students to understand science modeling practices needed**

Informed Next Steps: Later Iterations and Testing of the Approach

- **Semester-long sequence** of Text-Based Investigation modules for high school biology to socialize students into new practices
- **Learning progression** to guide teachers in spotlighting and stepping up student learning goals across semester, linked to curriculum
- **Mini-module focused on science modeling** to build deeper understanding of explanatory models and their role in testing science ideas
- **Professional development** to support novice teachers in doing, practicing, learning from Text-Based Investigations, drawn from Teacher Inquiry Networks
- **Efficacy trial** (RCT) looking at teacher as well as student learning (epistemology surveys, science reading assessments)

Final Steps: Studying Impact on Teacher Practice to Shift Student OTL

–Condensed professional development experiences for teachers

- 4 days winter introduction to Reading Apprenticeship routines
- 5 days summer work with texts, tasks, and Text-Based Investigations
- 2 days support during Fall implementation

–Instructional resources, tools and scaffolds

- Guidance for text selection
- Potential texts and Text-Based Investigations in sequence
- Learning Progression

Study Design

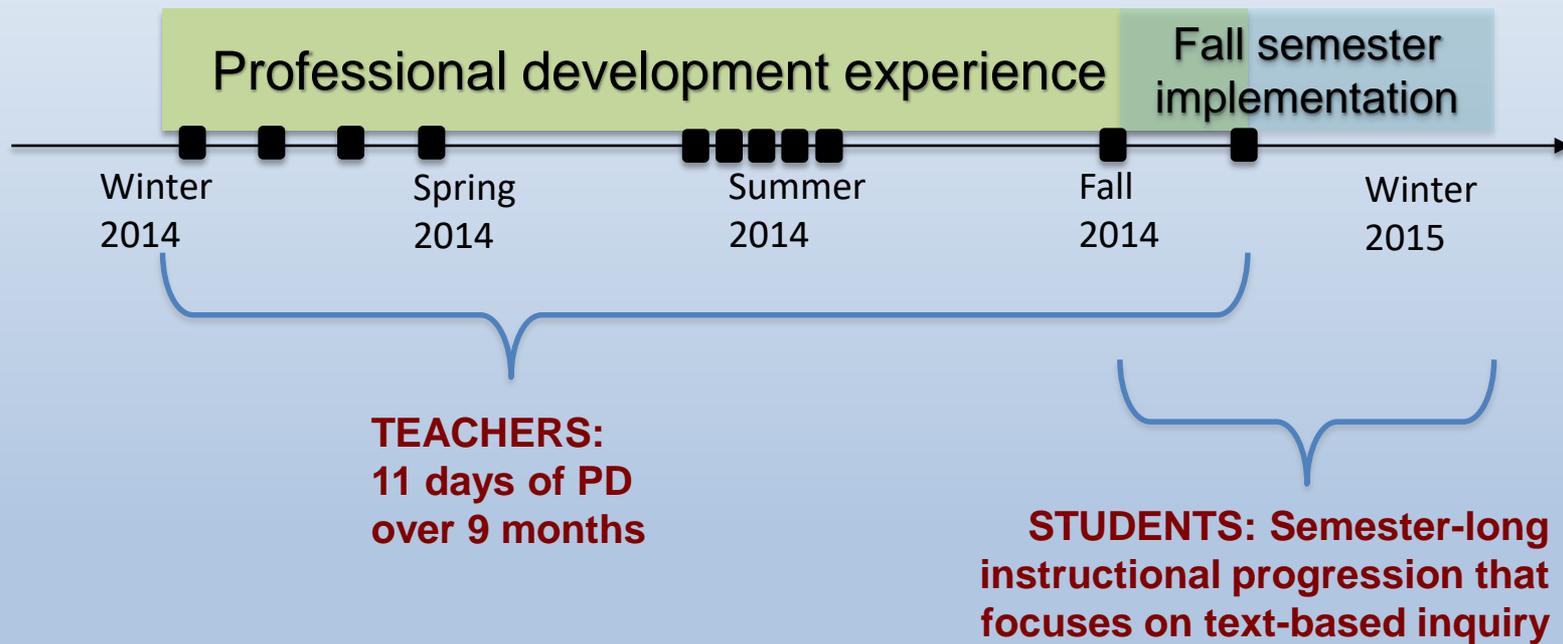
- Stratified Random Sample at School Level
 - Stratification based on prior school level achievement
 - **12 High Schools** assigned to **Intervention** and **12 High Schools** to **Comparison**
- Participants
 - **24 biology teachers** in each condition:
 - READI intervention; Comparison – Instruction as usual
 - Randomly selected **two classes from each teacher**
 - Approximately **2400 students**
 - Analyzable data from approximately 1000 students

To support students in Reading for Understanding in Science, science teachers will need to:

- understand science literacy practices and texts
- understand science investigation practices
- value their utility for student learning in science
- have the repertoire of practices that support students in engaging in text-based investigations

Teachers mediate students' opportunities to learn

Constraints and Challenges: Timeline for PD and Implementation





Enactment of inquiries to build insight and knowledge

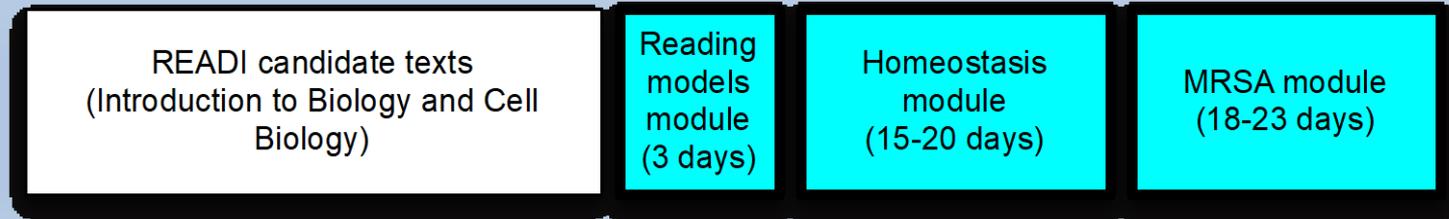
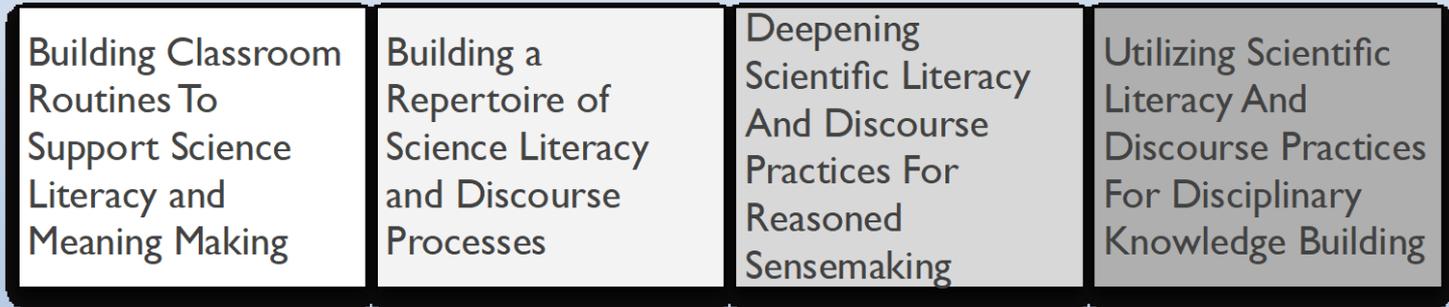
Drawing from the most impactful inquiry experiences in the
Teacher Inquiry Network

To compress teacher learning from four years of work into a
few months...

Supporting Generative Implementation

- GOAL: Support teacher capacity to foster learning environments that increasingly value reading for understanding in science
 - Classroom learning culture that **values, persists through, and resolves confusions when reading challenging sources**
 - Routines for classroom discussions that encourage students to **share, critique, and build knowledge using evidence**
 - A focus on **asking questions about and constructing, justifying, and critiquing explanations/models of science phenomena**

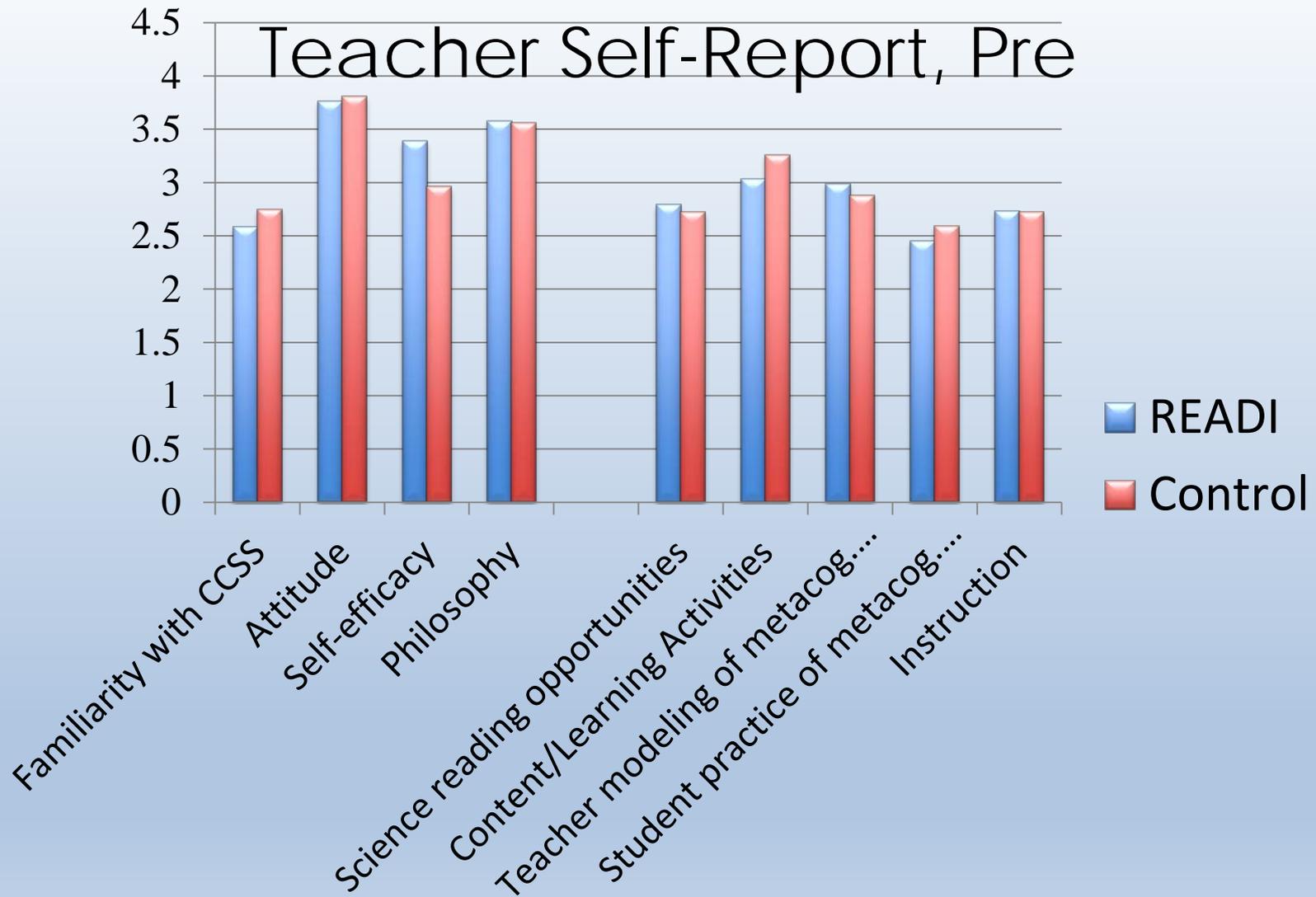
Instructional progression



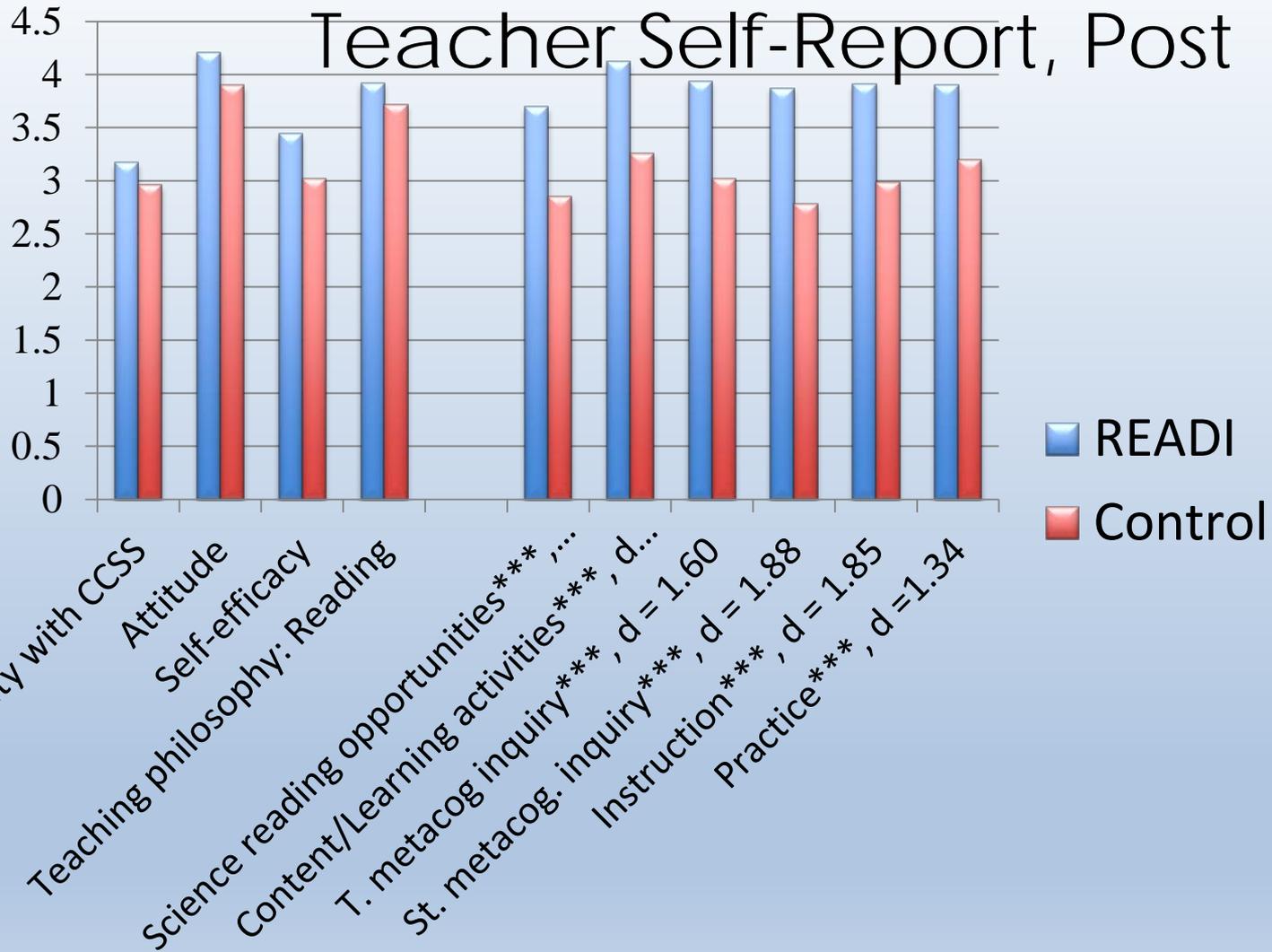
Impact Measures

- All Teachers
 - Self-Report Survey of knowledge, beliefs, practices
 - Administered prior to intervention teachers beginning professional development in Winter 2014. Re-administered in late winter 2015
 - Two classroom observations:
 - Early in semester
 - Late in semester
- All Students
 - Reading: RISE at pre, GISA at post
 - *Evidence-based argument from multiple sources (EBA) assessment aligned with READI Learning Objectives

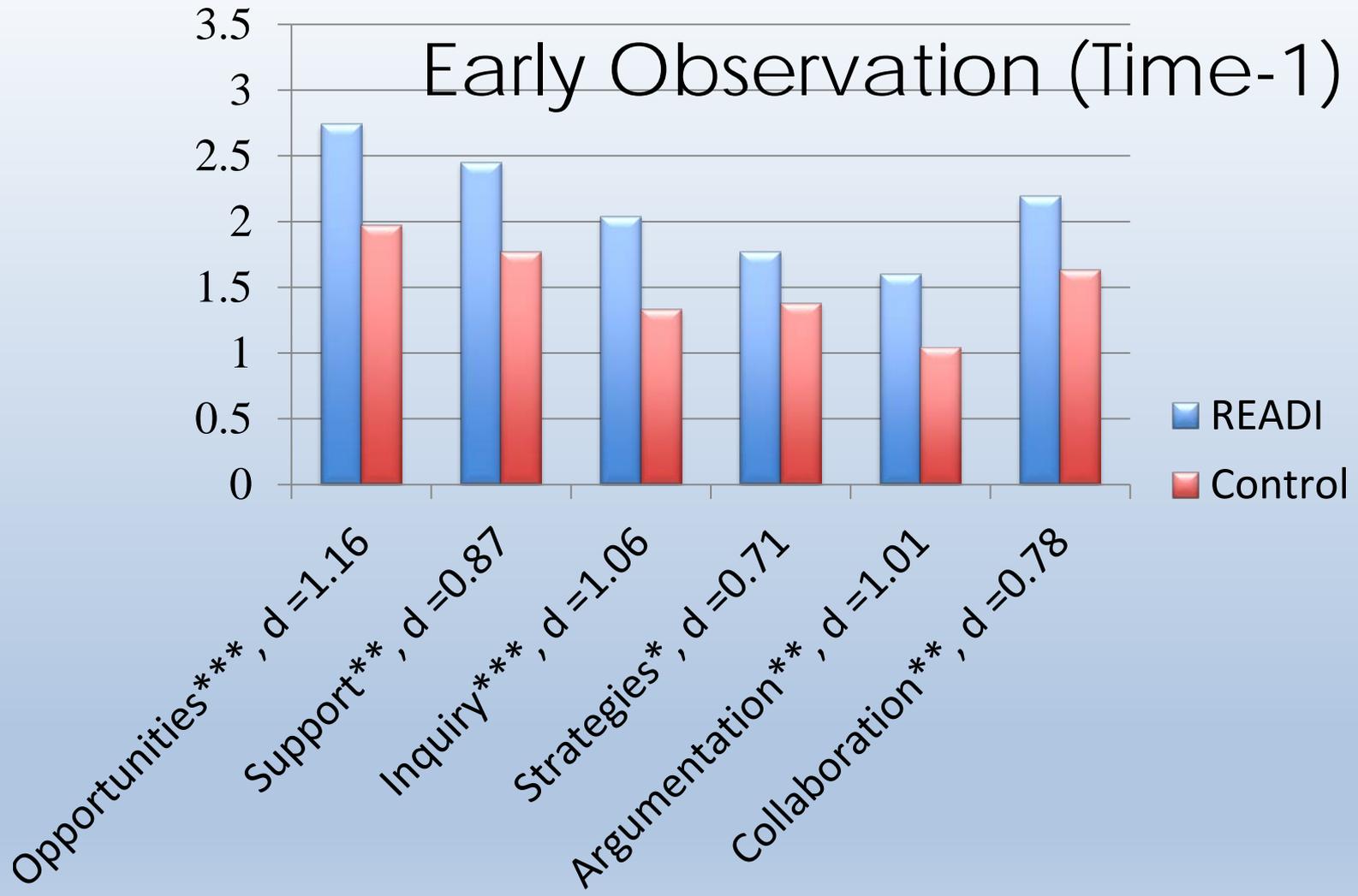
Teacher Self-Report, Pre



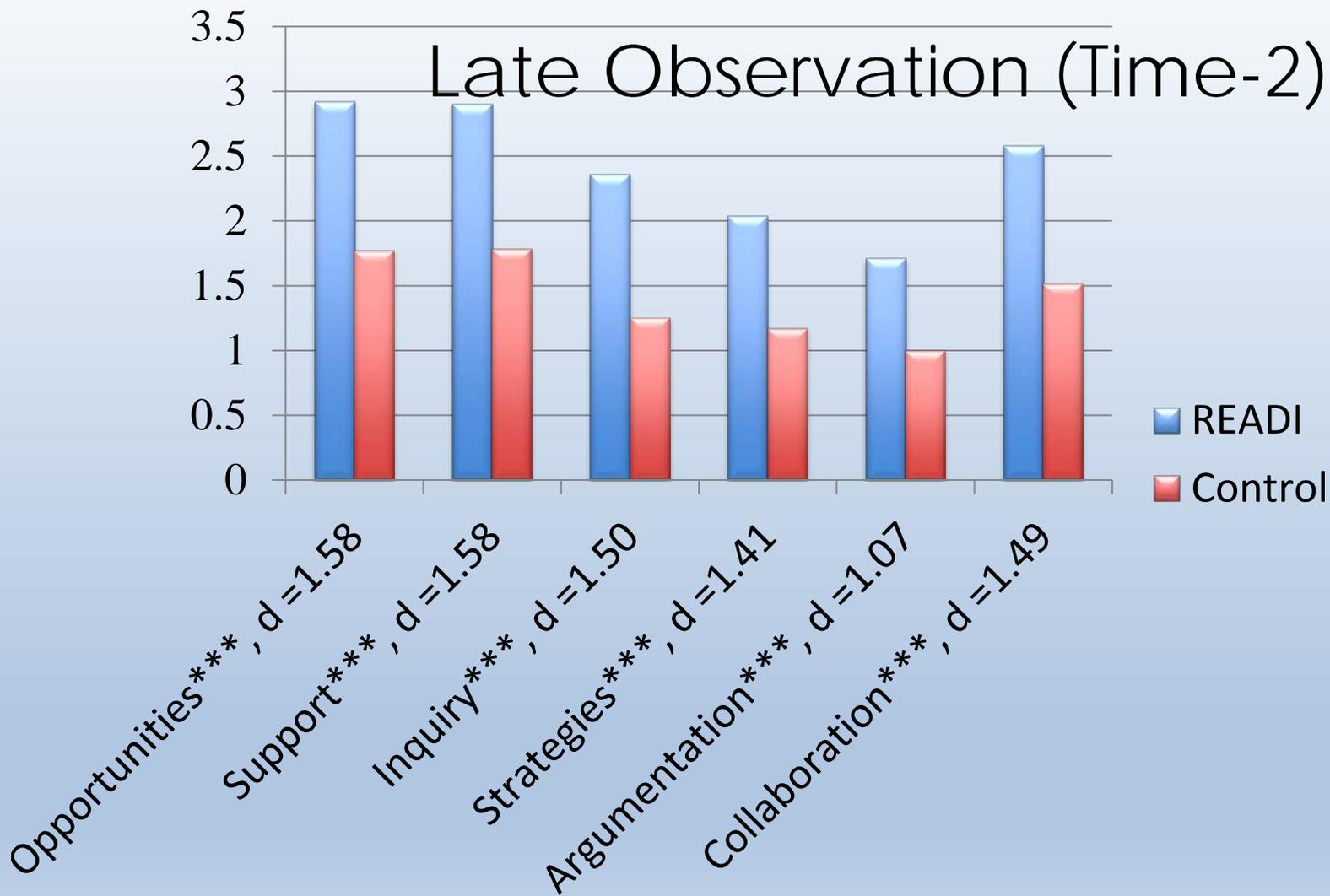
Teacher Self-Report, Post



Early Observation (Time-1)



Late Observation (Time-2)



Scenario Based Assessment

- Hello. During this session, you are going to take a new kind of test. In it, you will imagine that you are in your Biology class and that you are having a guest teacher today. The guest teacher is a scientist from the local college.
- Pay close attention to everything in this test, including what your classmates say to you and to each other. Participate in the conversations. All the information is important and will help you answer the questions.
- To move from screen to screen after you have read a text or answered a question, click the arrow at the top of the screen. If you have any questions, raise your hand.
- Click the arrow to meet your teachers and classmates.



Angie

Angie won the school science fair in 8th grade, but her favorite subject this year is History.



Louis

Louis's best subject is math. He does pretty well in Biology, too.



Ted

Ted likes science, but he's struggling in Biology class this year.



Mitochondrial DNA

Parents give their children many things throughout their lives. One of the things naturally passed along from parents to children are their genes. Although both parents pass along their nuclear DNA, moms are single-handedly responsible for passing along an identical copy of their mitochondrial DNA to their children.

The mitochondria are often referred to as the “powerhouse” of cells. This cell part is essential to the human body because it converts energy from food in a process called oxidative phosphorylation. Mitochondrial DNA, abbreviated mtDNA, is found within the mitochondria of cells. Mitochondrial DNA is similar to the better known nuclear DNA in that they both contain information about a person’s genetic makeup; however, in many other ways, the two types of DNA are different. mtDNA is located outside of the nucleus of cells, while nuclear DNA can be found within the nucleus. In addition, there are many more copies of mtDNA found throughout the body. The reason for this is that each cell has a single nucleus that contains a single copy of DNA, but there are multiple mitochondrion in a single cell. Each mitochondrion contains many copies of mtDNA. Mitochondrial DNA is also different from Nuclear DNA in that it is inherited directly from the mother. In contrast, nuclear DNA comes from both the mother and father. As a result, Mitochondrial DNA remains largely unchanged across generations.

Both Nuclear DNA and Mitochondrial DNA can be used to examine family heritage but only Mitochondrial DNA can be used to show the relationship between modern species and

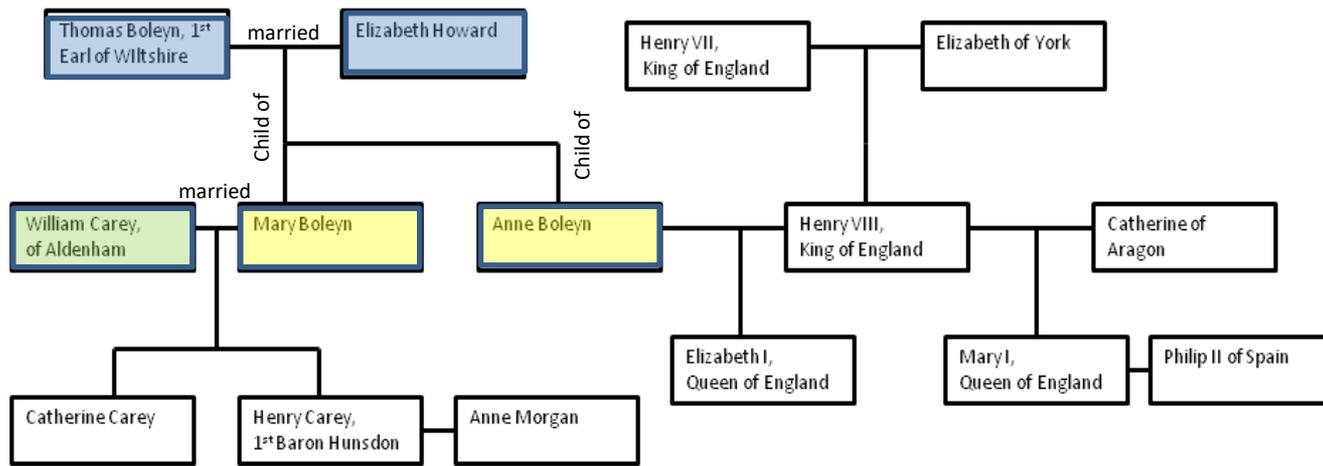


Dr. Sloane

One of the most important concepts in the article is that mtDNA and nuclear DNA have meaningful similarities and differences.

Fill out the table below to show which attributes describe mtDNA, which describe nuclear DNA, and which describe both. Click in the appropriate table cells for each statement.

| Statement | mtDNA | Nuclear DNA | Both | Neither |
|--|-------|-------------|------|---------|
| Many copies exist in each cell of the body | | | | |
| Children receive copies from both parents | | | | |
| Remains in a scientifically useful state after 500 years | | | | |
| Contains genetic information | | | | |
| Remains largely unchanged across generations | | | | |



Dr. Sloane

When reading a genealogy chart, **horizontal** lines show marriages, and **vertical** lines show children or offspring of the married pair.

For example, Mary and Anne Boleyn (shaded yellow) are children of married couple Thomas Boleyn and Elizabeth Howard (shaded light blue).

William Carey (Shaded green) married Mary Boleyn but was not related to her parents.



Directions: Read the article that Angie sent.

The First Americans: Did They Cross the Pacific or the Atlantic?

When Europeans arrived in the Americas in the 1400s, there were numerous Native American groups that populated both the North and South American continents. The scientific consensus is that these original Americans themselves had also migrated to the Americas. But from where and when? Anthropologists are currently working to find evidence that explains their geographic origins. Two competing theories currently exist: The Beringia Theory and The Solutrean Theory.

The Beringia Theory

The Beringia theory suggests that the first Americans came from Asia by migrating across the Bering Land Bridge that connected the lands that are now known as Siberia and Alaska. During the last Ice Age, about 13,000 years ago, much of the world's fresh water was captured in ice sheets and glaciers. These massive ice sheets resulted in lower sea levels, which in turn created the Bering Land Bridge across the Pacific Ocean between Siberia and Alaska. This land bridge is thought to have been hundreds of miles wide.

Providing support for this theory are animal fossils from western Canada and Alaska. These fossils are considered evidence that large mammals crossed into North America on this land bridge, fleeing the ice that was moving eastward across Siberia in Asia. Following these herds of animals were humans who were hunters and gatherers and depended on these mammals as a major source of food. Additionally, relics of ancient peoples' stone tools have been found in archaeological sites across the western part of North America.

The Solutrean Theory

The Solutrean theory, on the other hand, proposes that the first Americans came from Europe by crossing the Atlantic rather than the Pacific Ocean. This theory was proposed in the 1930s and resurrected in the late 1990s, when the discovery of tools between 18,000 and 26,000 years old at six sites in the eastern United States cast suspicion on the Beringia theory. These tools strongly resemble those of the Solutreans, people who disappeared from northern Spain and France between 24,000 and 16,500 years ago.

For many years, the Beringia theory was widely accepted. But recently, the Solutrean theory has been gaining more attention. As Michael Waters, director of the Center for the Study of the First Americans at Texas A&M University points out, we need additional evidence to determine which theory is most accurate.



Fig. 1. Map of the World



The Beringia Theory

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Dr. Sloane

Read each statement and decide if it is a claim that is made by the Beringia theory or the Solutrean theory.

Put an X in the appropriate box for each statement.

| Claim | Beringia Theory | Solutrean Theory | Neither |
|--|-----------------|------------------|---------|
| The first Americans came from Asia. | | | |
| The first Americans came from Europe. | | | |
| The first Americans crossed a land bridge that existed during the Last Ice Age. | | | |
| The first Americans crossed the Atlantic Ocean. | | | |
| The first Americans built permanent shelters. | | | |
| Large mammal fossils are found submerged at the bottom of sea between Alaska and Siberia. | | | |
| The oldest American settlement site to date is discovered in the Amazon Jungle in South America. | | | |



The Beringia Theory

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Dr. Sloane

Now, In the spaces below, summarize the evidence presented that supports each theory.

Make sure the summaries are in your own words, include all the important evidence in support of each, and do not include your own opinions.

Summarize the evidence for the Beringia Theory in 2-3 sentences:

Summarize the evidence for the Solutrean Theory in 2-3 sentences:

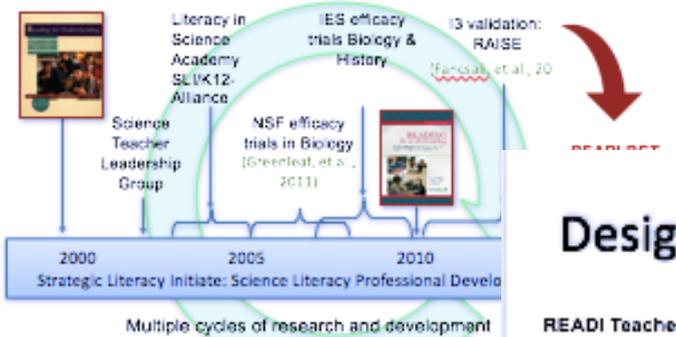
The evidence that supports the Solutrean theory is the discovery in the eastern U.S. of stone tools that are between 18,000 and 26,000 years old. These stone tools are very similar to the tools used by the Solutrean people, who once lived in Northern Spain and France.

Student Assessment Outcomes

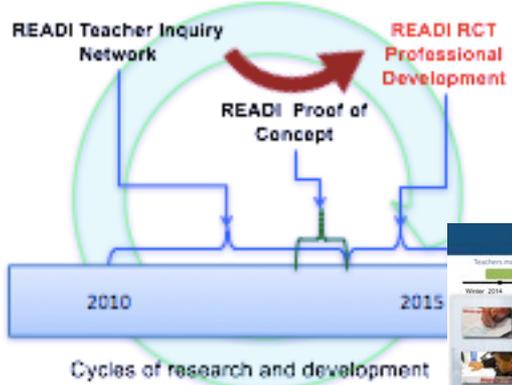
- There were no statistically significant differences between Intervention and Control groups on the RISE administered at the beginning of the school year
- Students in the READI classrooms **outperformed the comparison students on the GISA** administered at the end of the intervention ($p < .05$; $ES = 0.32$)
- Students in the Intervention condition **scored significant higher** than the Control group **on the multiple choice measure of the EBA Assessment** ($p < .01$; $ES = 0.26$)
- HLM analysis confirmed Intervention students scored higher on the EBA multiple choice and GISA assessments than Control students

Making the Road by Walking

Builds upon prior work



Design-based research



READI for 9th Grade Biology: Yes They Can

Teachers moderate students' opportunities to learn. Teachers build opportunities to engage with the knowledge, skills, and practices they will facilitate for their students.

Timeline: Winter 2014, Spring 2014, Summer 2014, Fall 2014, Winter 2015

READI RCT Professional Development: Integrating Reading Apprenticeship and READI Learning Goals

READI Practices x Content

Study Design

Results

PROJ READI

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

WestEd

Planning modules into the semester

Days 10-11 Deepening science literacy and discourse: modules as educative curricula, formative assessment & responsive instruction

- exposition
- Synthesize evidence and information across multiple sources including graphs, diagrams, models, exposition
- Construct, justify, and critique explanations and explanatory models of science phenomena from scientific evidence drawn from multiple sources and using science principles, frameworks, and enduring understandings
- Demonstrate understanding of the epistemology of science through inquiry dispositions and conceptual change awareness/orientation; generate inquiry questions, monitor their changing conceptions through multiple encounters with text, tolerate ambiguity, seek "best understandings given the evidence."

Discourse routines to support science literacy and meaning making

repertoire of science literacy and discourse practices

scientific literacy and discourse practices for reasoned sensemaking

science literacy and literacy practices for knowledge building



Discourse routines



Metacognitive routines



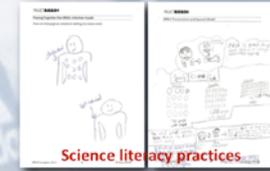
Discourse routines



Instructional Strategies & Decisions



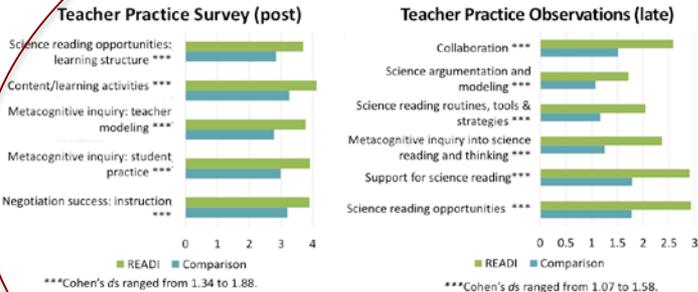
Reading in science



Science literacy practices

Results

TEACHERS: READI and comparison teachers did not differ on survey responses prior to PD. There were significant differences between the two on all constructs related to practices at the conclusion of the intervention, with **READI teachers showing significantly higher ratings.**



STUDENTS: READI and comparison students did not differ on comprehension at pre. Post intervention **READI students outperformed comparison students** on the ETS-developed GISA multiple source comprehension assessment.

| Student Learning Outcomes | READI n = 672 | Comparison n = 539 |
|---|------------------|-----------------------|
| Post | | |
| GISA (post)*** | 58.76% (16.14) | 54.85% (17.36) |
| Science epistemology scale 1: Corroboration using multiple sources** | 4.86 (0.69) | 4.74 (0.75) |
| Science epistemology scale 2: Science is tentative and complex, not simple and certain | 2.94 (0.83) | 2.92 (0.82) |
| Self-efficacy/confidence in doing science | 3.58 (0.84) | 3.53 (0.84) |
| Pre | | |
| RISE | 271.33 (13.47) | 270.01 (13.95) |
| Science epistemology scale 1: Corroboration using multiple sources | 4.81 (0.68) | 4.83 (0.72) |
| Science epistemology scale 2: Science is tentative and complex, not simple and certain* | 2.76 (0.81) | 2.85 (0.81) |
| Self-efficacy/confidence in doing science | 3.60 (0.81) | 3.62 (0.79) |

Note. * p < .05; **p < .01. *** p < .001.

A. Marple, Irina Chamey-Sirot, Susan Goldman, Thomas Griffin, Mariya Yuhomenko

PROJECT READI
http://www.projectreadi.org/

inquiryium

Northern Illinois University

NORTHWESTERN UNIVERSITY

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

WestEd
http://readingapprenticeship.org/

Funded by the Reading for Understanding Initiative of the Institute for Education Sciences, U.S. Department of Education, through Grant R305F100007 to University of Illinois at Chicago. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

PROJECT READI

inquiryium

Northern Illinois University

NORTHWESTERN UNIVERSITY

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

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What would it take to make evidence-based argument from multiple sources the very definition of reading for understanding?

- Collaboration across researchers, observers, teachers, students
 - Participant learning focused on experiencing and unpacking target tasks (metacognitive conversation)
- Curriculum Resources
 - Worthy, authentic texts
 - Engaging investigation tasks consonant with disciplinary activity
 - Shared principles of construction
 - Spotlights on challenges
- Conceptual Tools
 - Learning goals
 - Instructional sequences
- Pedagogical Tools
 - Instructional routines
 - Scaffolds for reading, reasoning, discussion, and argumentation

What would it take to make evidence-based argument from multiple sources the very definition of reading for understanding?

- Assessment Tools
 - New ways of measuring reading for understanding
- Time
 - For teacher learning and support for new practices
 - For student learning and support for new practices
- Funding
 - Lots of it
- While a huge endeavor, we touched a tiny fraction of the students who move through the US school system each year

..miles to go before we sleep



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Case Library

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Thank you

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