Seeds of Science/Roots of Reading
An Integrated Approach to Science and Literacy Instruction

STEM Smart: Lessons Learned
from Successful Schools
Las Vegas, NV
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Seeds of Science/Roots of Reading

…a curriculum development *and* research project

www.scienceandliteracy.org

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Common Approaches to Teaching Science

Inquiry-Only Approaches	**Text-Only Approaches**
Hands-On Experiences	Reading
Discussions	Writing

The *Seeds/Roots* Approach to Teaching Science

Inquiry-Only Approaches		**Text-Only Approaches**
Hands-On Experiences	**Do It**	Reading
Discussions	**Talk It**	Writing
	Read It	
	Write It	

Engage students through multiple learning modalities.

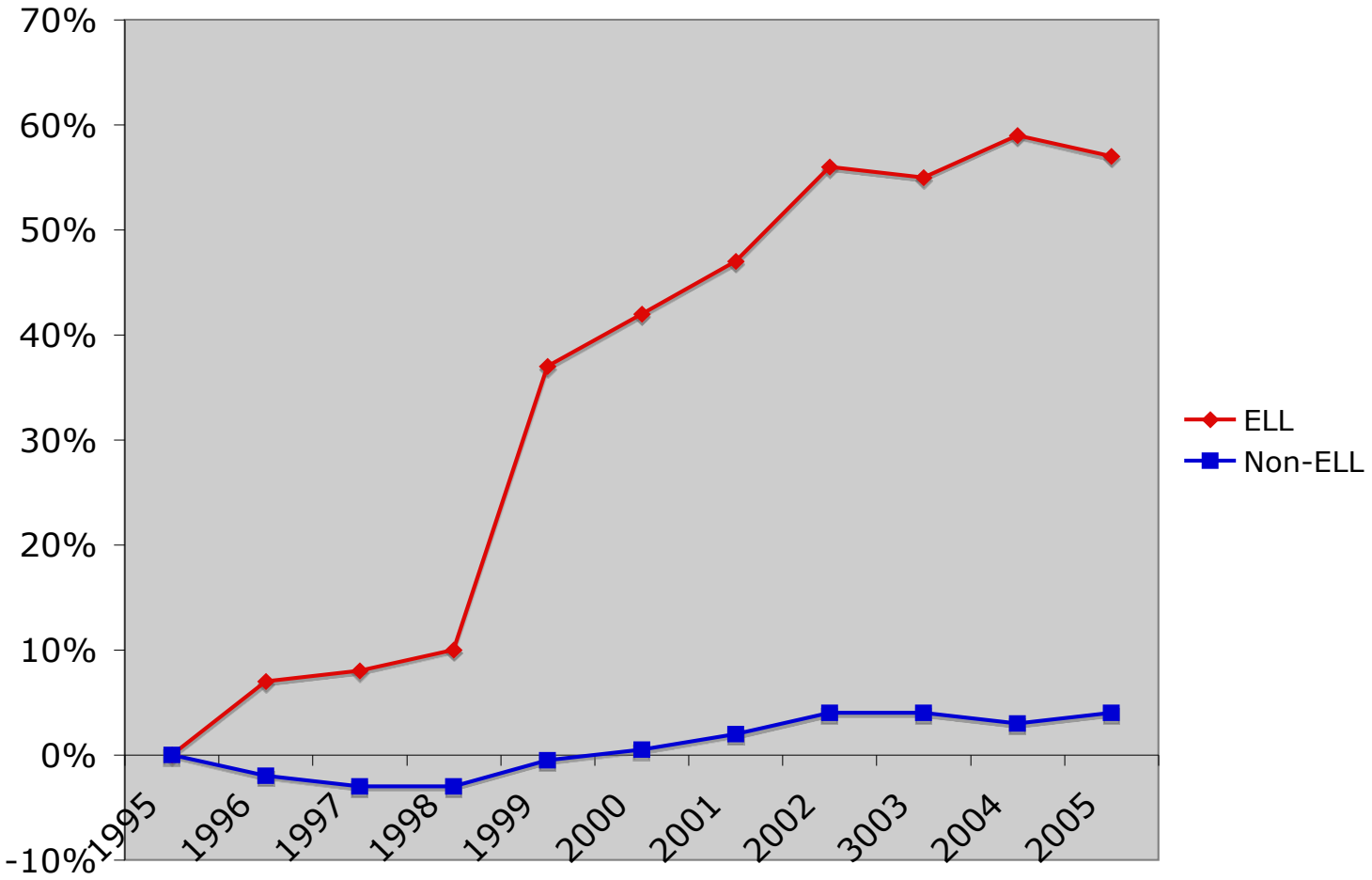
Seeds of Science/Roots of Reading offers an effective approach for enacting Goal 3 of the NRC Report: *Successful K-12 STEM Education*

Increase STEM literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines.

Challenges to address

- The population of school-age English language learners in US schools is growing
- And yet, most instructional materials are written for use with English speakers, leaving the teacher to make necessary accommodations for English learners

ELL/Non-ELL Growth ‘95-’05



Achievement Gap

4th Grade Reading Performance (NAEP 2011)

	Average Scale Score	At or above Basic	At or above Proficient
ELL	191	31%	7%
Non ELL	227	72%	37%

4th Grade Science Performance (NAEP 2009)

	Average Scale Score	At or above Basic	At or above Proficient
ELL	116	33%	5%
Non ELL	156	76%	37%

We drew from the research base

- Review of existing research and literature on effective practices for ELLs, found at

http://www.scienceandliteracy.org/research/english_language_learners

- Used the results to inform the development of:
  - the instruction for students
  - notes to the teacher about how to accommodate

Four Principles that Make Science Accessible for ELLs

1. Provide Additional Scaffolds for Language *-Making abstract concepts more concrete*	**2. Make Connections to Students' Linguistic Resources** *-Leveraging students' native language*
3. Provide Additional Opportunities for Practice *- Repeated access to science concepts through multiple modalities*	**4. Support the Development of Strategic Behavior** *-Build self-monitoring language abilities*

Goals for Today's Workshop

- Engage you in our multi-modal approach to science instruction, using activities from one unit, *Light Energy*
- Provide evidence from a study focused on the impact of the educative features of the Seeds/Roots curriculum on teacher practices as related to providing ELLs with access to science
- Provide evidence from efficacy studies focused on the Seeds/Roots multi-modal approach, including how ELL students perform

Shared Listening

Partner A listens, while Partner B talks.

What challenges are there for English language learners in your district in learning science?

Partner A summarizes what they heard.

Partner B listens, while Partner A talks.

What are the ways that you have provided, or supported others in providing, English language learners with access to science?

Partner B summarizes what they heard.

2nd-5th Grade Scope and Sequence

Focus for Today

Life Science	Earth Science	Physical Science
Grades 2–3		
Soil Habitats	Shoreline Science	Designing Mixtures Gravity and Magnetism
Grades 3–4		
Digestion and Body Systems Variation and Adaptation	Weather and Water	Light Energy
Grades 4–5		
Aquatic Ecosystems	Planets and Moons	Models of Matter Chemical Changes

Unit Components

Teacher's Guide

LEFT-HAND PAGE: *Step-by-step presentation of the session*

SESSION SUMMARY
Includes what students learn

UNIT LEARNING GOALS
Overall learning goals are summarized at the beginning of each session

MATERIALS/PREPARATION
Where to find detailed information on materials and preparation necessary for each session

TIME FRAME
Pacing for each activity

STEP-BY-STEP INSTRUCTIONS
Suggestions for teaching the session, including thoughtfully worded prompts

SCIENCE STANDARDS
Daily correlation "snapshots"

SESSION 1.1
Into the Soil
READING

INVESTIGATION 1
Soil and Decomposition

UNIT GOALS

Science Knowledge/Conceptual Vocabulary
- properties of earth materials—soil
- life processes—decomposition
- organisms and habitat
- plant and animal adaptations

Science Inquiry/Reading Comprehension

Inquiry
- observing and questioning
- investigating and modeling
- analyzing data and drawing conclusions

Comprehension
- reading science texts
- using comprehension strategies
- understanding and using text features to locate information

Nature and Practices of Science/Oral and Written Discourse

Nature and Practices of Science
- understanding that science knowledge is based on evidence
- distinguishing observations from inferences
- understanding how scientists engage in the practices of science

Discourse
- acquiring scientific language
- writing informational text for various purposes
- participating in scientific discourse

Summary

Students activate their prior knowledge about soil and read the book, Into the Soil. This first book in the unit introduces students to the concept of soil, playing on the fact that soil is everywhere but we don't really think about it much. It uses a playful riddle structure to invite readers into the subject. Students are introduced to their investigation Notebooks—the place where they will record their observations and reflections over the course of the unit.

Students learn:
- soil covers much of the Earth
- living things depend on soil
- soil is a home for some animals
- soil helps plants grow
- humans depend on soil to provide their food

What You Need and Getting Ready

Information on preparing for this session can be found on page 4.

Time Frame

	Estimated Time
Introducing the Unit	5 minutes
Introducing Investigation Notebooks	5 minutes
Before Reading	10 minutes
During Reading	15 minutes
After Reading	15 minutes
Introducing Key Concepts and Concept Wall	10 minutes
TOTAL	60 minutes

Introducing the Unit

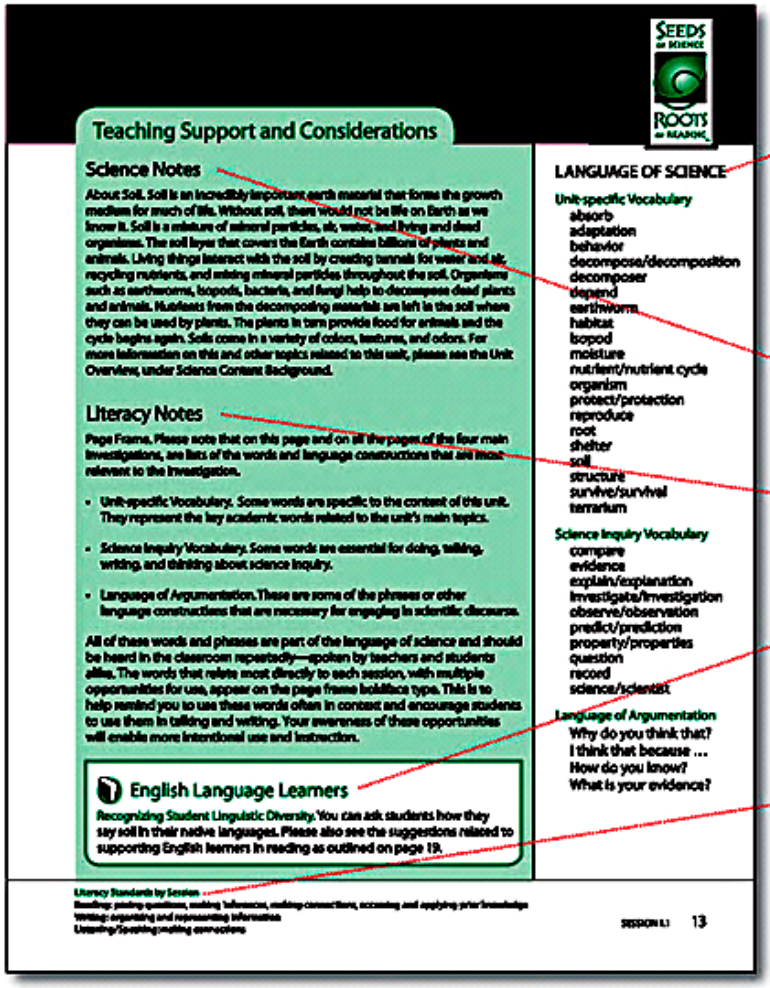
1. **Launch unit.** Tell the class that they are starting a new science unit called Soil Habitats. Say that they will be exploring soil and some of the animals that make their homes in the soil.
2. **Introduce investigations.** Tell students that they will learn about soil and the animals that live in soil by reading, talking with one another, and by doing investigations. Investigation is one of the ways scientists learn about the natural world. Investigate means to study carefully.

Science Standards by Session
Inquiry: accessing and applying prior knowledge, investigating scientific questions
Science Concepts: soil as a resource, relationship of soil to living things

12 SOIL HABITATS

Teacher's Guide

RIGHT-HAND PAGE: *Teaching Support and Considerations*



Teaching Support and Considerations

Science Notes

About Soil. Soil is an incredibly important earth material that forms the growth medium for much of life. Without soil, there would not be life on Earth as we know it. Soil is a mixture of mineral particles, air, water, and living and dead organisms. The soil layer that covers the Earth contains billions of plants and animals. Living things interact with the soil by creating tunnels for water and air, recycling nutrients, and mixing mineral particles throughout the soil. Organisms such as earthworms, isopods, bacteria, and fungi help to decompose dead plants and animals. Nutrients from the decomposing materials are left in the soil where they can be used by plants. The plants in turn provide food for animals and the cycle begins again. Soils come in a variety of colors, textures, and odors. For more information on this and other topics related to this unit, please see the Unit Overview, under Science Content Background.

Literacy Notes

Page Frame. Please note that on this page and on all the pages of the four main investigations, are lists of the words and language constructions that are most relevant to the investigation.

- Unit-specific Vocabulary. Some words are specific to the content of this unit. They represent the key academic words related to the unit's main topics.
- Science Inquiry Vocabulary. Some words are essential for doing, talking, writing, and thinking about science inquiry.
- Language of Argumentation. These are some of the phrases or other language constructions that are necessary for engaging in scientific discourse.

All of these words and phrases are part of the language of science and should be heard in the classroom repeatedly—spoken by teachers and students alike. The words that relate most directly to each session, with multiple opportunities for use, appear on the page frame boldface type. This is to help remind you to use these words often in context and encourage students to use them in talking and writing. Your awareness of these opportunities will enable more intentional use and instruction.

English Language Learners

Recognizing Student Linguistic Diversity. You can ask students how they say soil in their native languages. Please also see the suggestions related to supporting English learners in reading as outlined on page 19.

LANGUAGE OF SCIENCE

Unit-specific Vocabulary
absorb
adaptation
behavior
decompose/decomposition
decomposer
depend
earthworm
habitat
isopod
moisture
nutrient/nutrient cycle
organism
protect/protection
reproduce
root
shelter
soil
structure
survive/survival
terrarium

Science Inquiry Vocabulary
compare
evidence
explain/explanation
investigate/investigation
observe/observation
predict/prediction
property/properties
question
record
science/scientist

Language of Argumentation
Why do you think that?
I think that because ...
How do you know?
What is your evidence?

Literacy Standards by Session
Reading: posing questions, making inferences, making connections, accessing and applying prior knowledge
Writing: organizing and representing information
Listening/Speaking: making connections

SESSION 1.1 13

LANGUAGE OF SCIENCE
The unit's key vocabulary as well as prompts to help students use the language of science. Vocabulary words include terms specific to each unit of study, as well as words about the process of scientific inquiry.

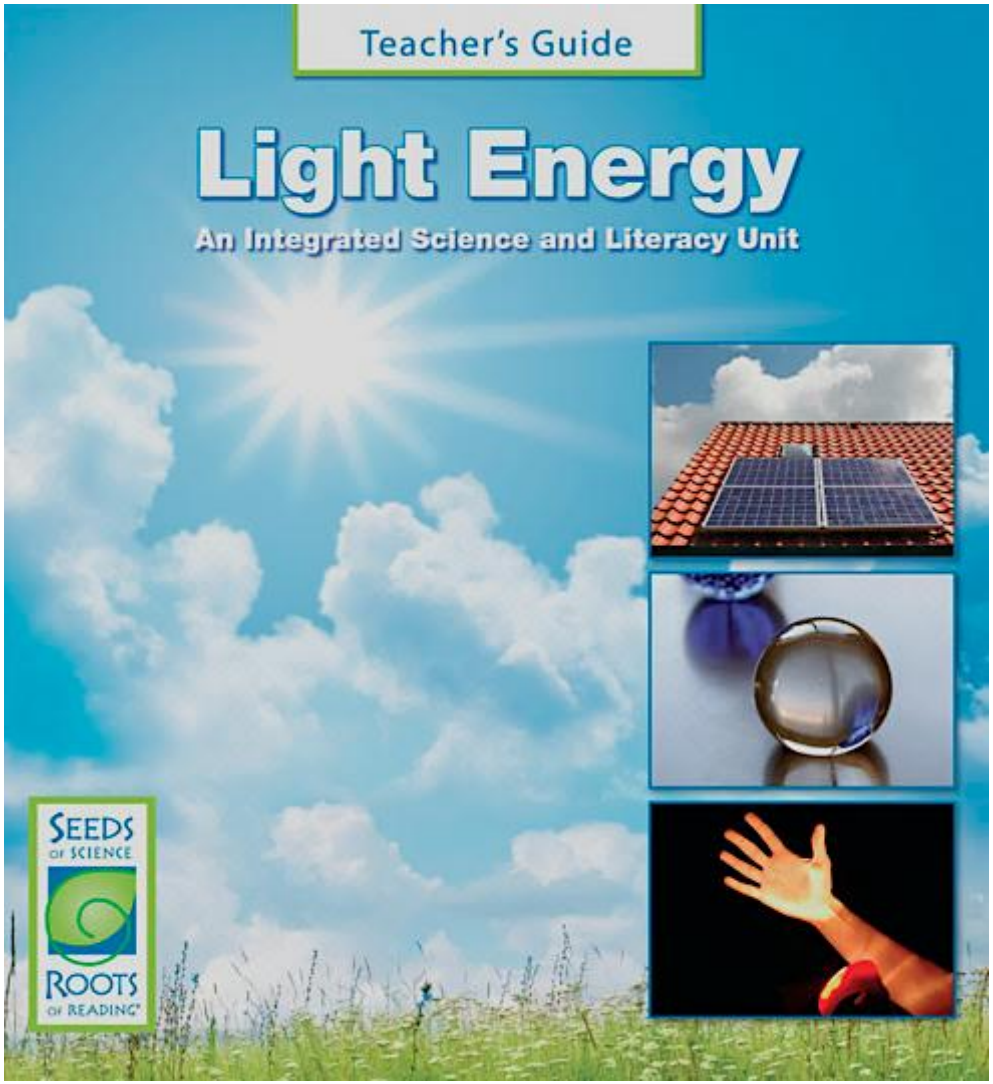
SCIENCE NOTES
Background information on the session's topic

LITERACY NOTES
Getting the most from the science-literacy connection

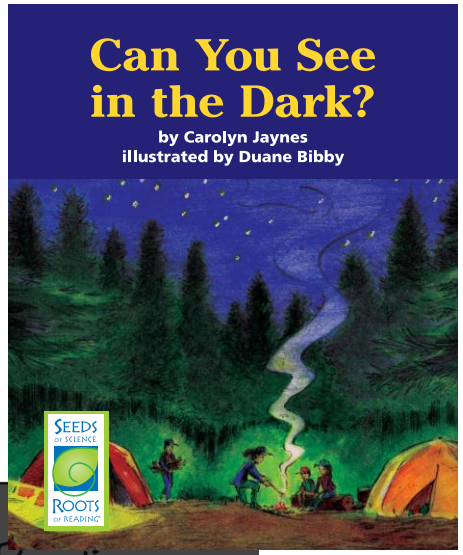
ENGLISH LANGUAGE LEARNERS
Strategies to accommodate the needs and support the science and literacy learning of English Language Learners

LITERACY STANDARDS
Daily correlation "snapshots"

Let’s Experience this Firsthand!



Activate prior knowledge
Set norms

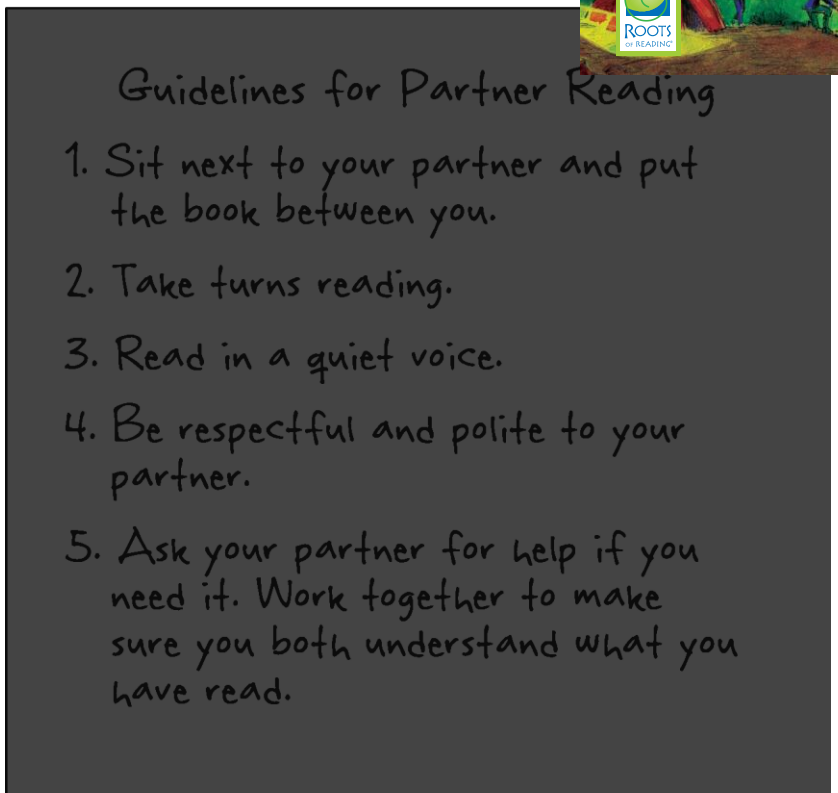


Read

Set context for investigations to come

Talk

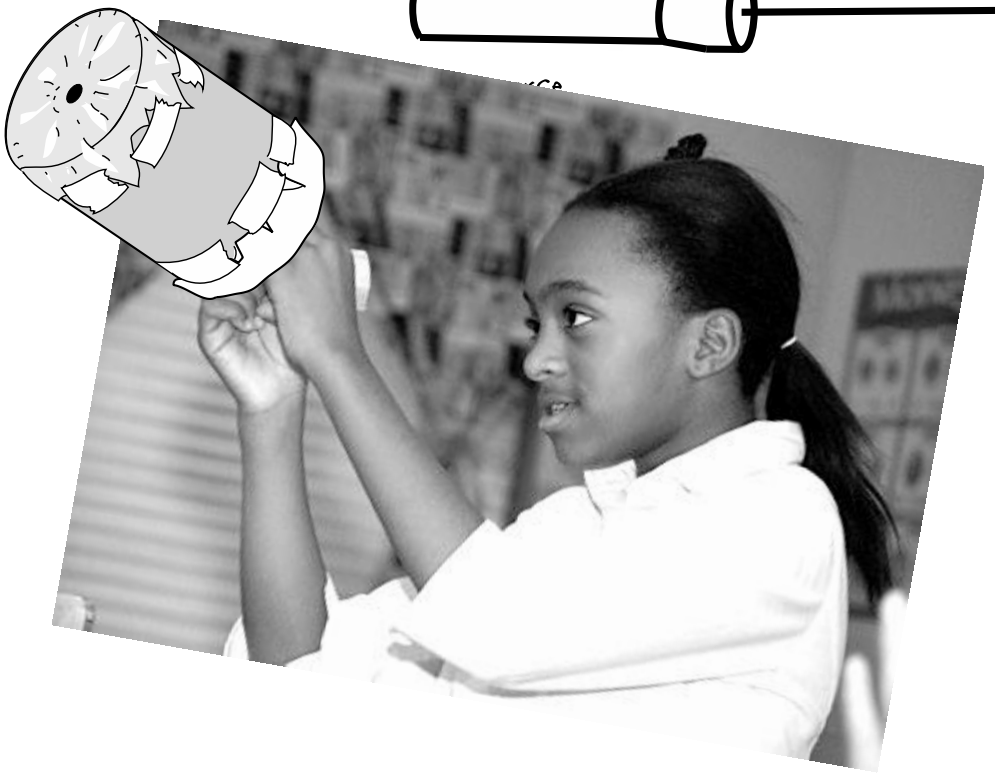
Build scientific community by developing routines for oral discourse



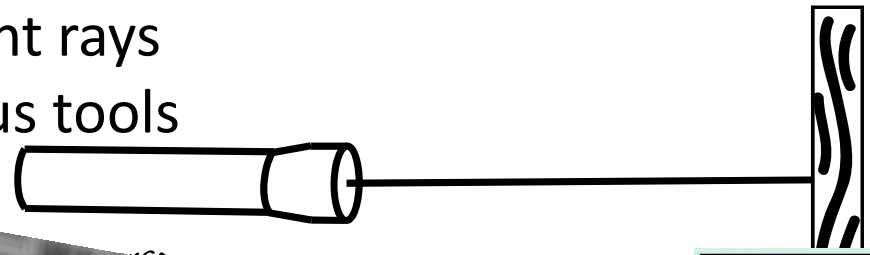
Search for evidence about the characteristics of light

Do

Explore light rays with various tools



Ray Diagram



Write

Create ray diagrams

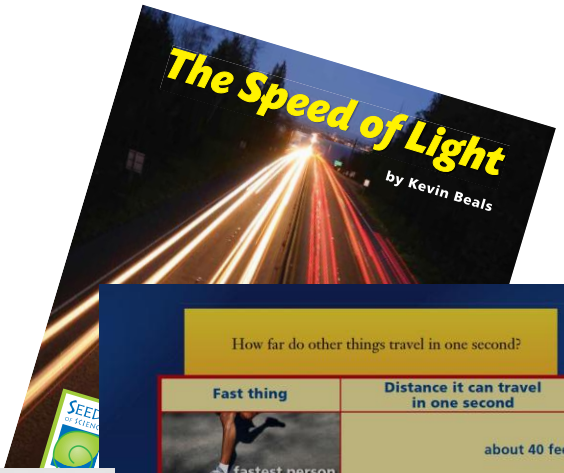
Observations About Light

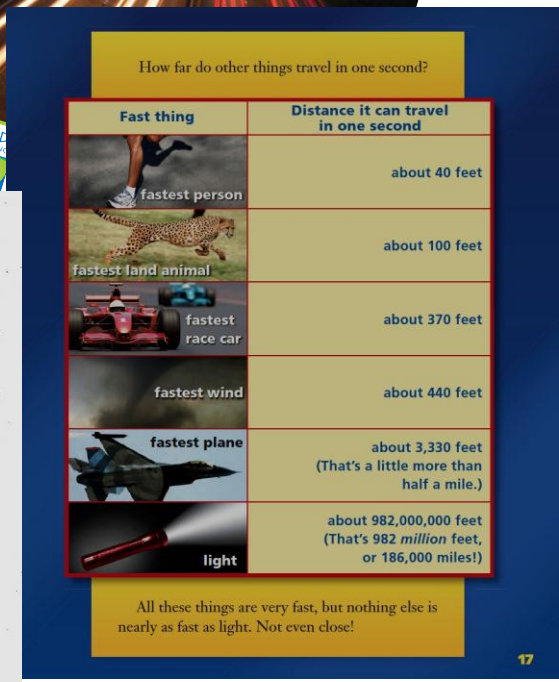
- flashlight made circle of light
- light seen through clear plastic
- foil - shiny in light
- circle of light got smaller when flashlight closer to foil
- light made black felt look silver/yellow
- light circle seen on back of felt

Read and Write Scientific Explanations

Read

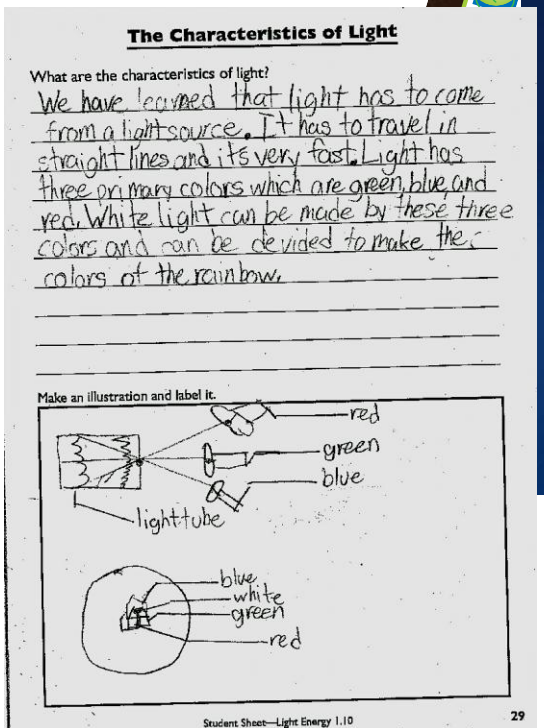
Secondhand investigation to gather more evidence about light



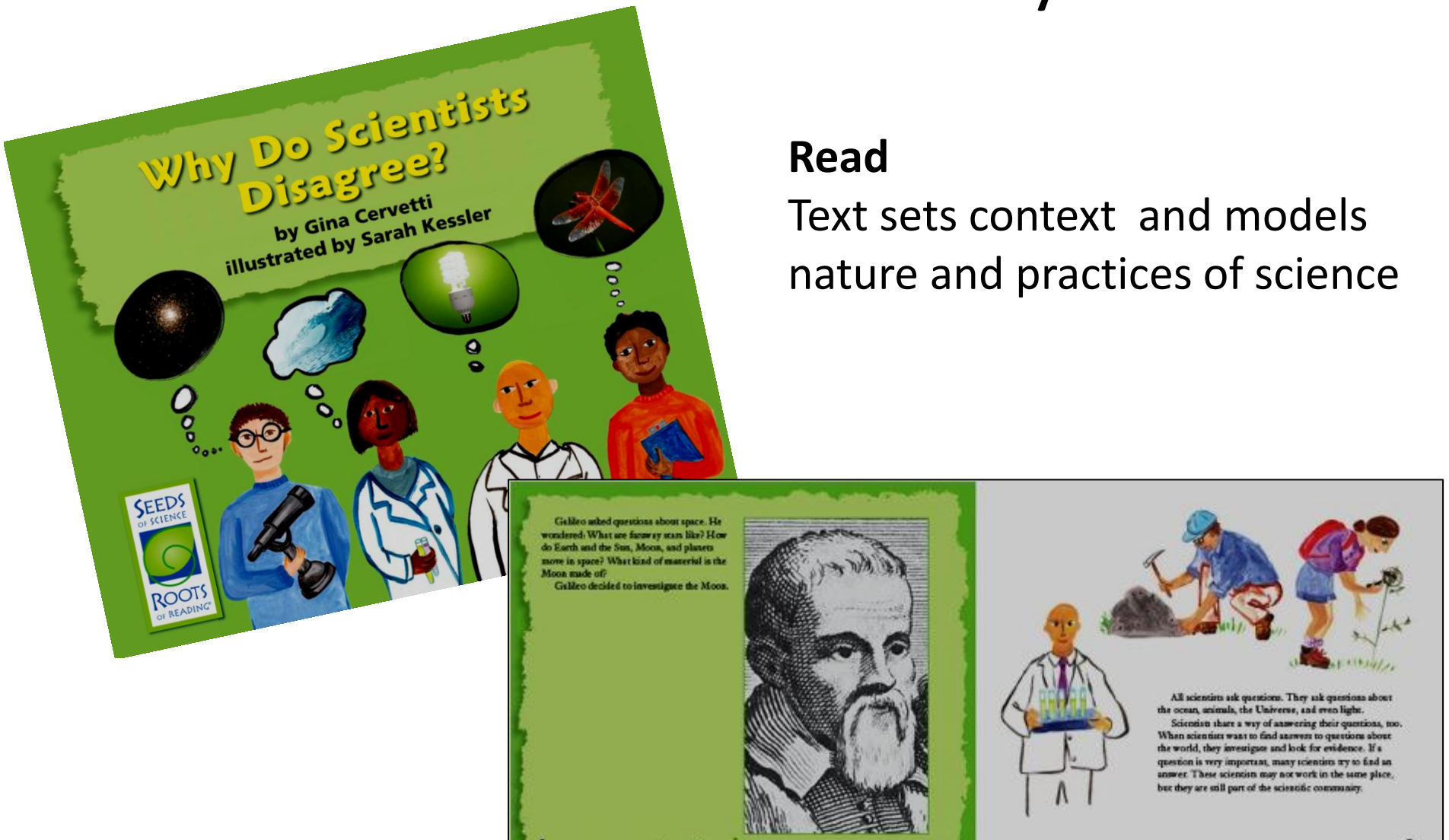


Write

Students make sense of the characteristics of light



Learn from the work of others in the scientific community



Read

Text sets context and models nature and practices of science

Investigate Properties of Light

Do

Students predict then measure how much light is

- reflected
- transmited
- blocked
- absorbed

when they shine light onto 10 different surfaces.

Which materials transmit light?

4 to a group

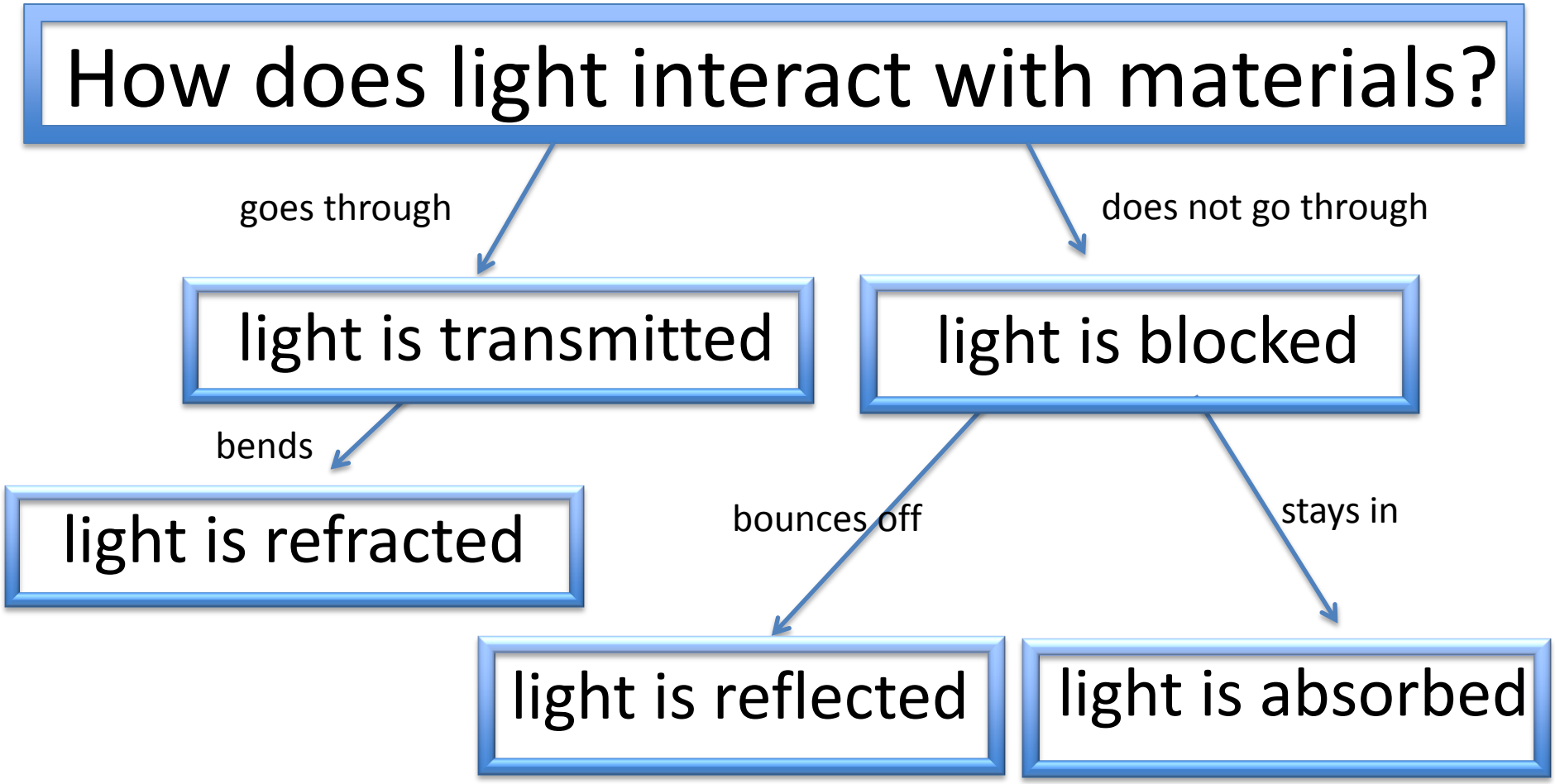
- Recorder
- Light detector holder
- Material/Flashlight holder
- Extra Pair of Hands

Which materials reflect light?

4 to a group

- Recorder
- Light detector holder
- Material/Flashlight holder
- Extra Pair of Hands

Light Interactions Concept Map



Search for additional evidence in text

Read

Students read a book that shares the results of someone else's investigation and search for evidence in the text about the interaction of light on various materials

Fabric

Fabric is the same as cloth. Fabric is made of thin **fibers** that are usually woven together. The fibers may be natural or made by people. Fabric is soft and easy to bend. These characteristics mean that fabric is good for making clothes, bags, bedsheets, and lots of other things. Different kinds of fabric can be smooth, bumpy, or even furry, and fabric comes in all different colors.

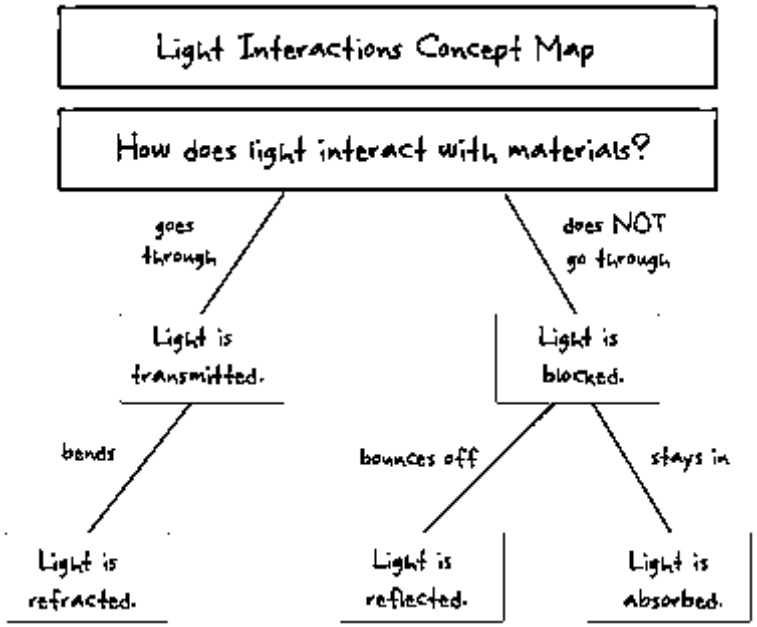
Material		Measurements			
		Brightness of light source	Transmitted light	Reflected light	Absorbed light
fake fur (yellow)		1,000 lux	207 lux	69 lux	724 lux
felt (black)		1,000 lux	23 lux	3 lux	974 lux
felt (red)		1,000 lux	104 lux	33 lux	863 lux
felt (white)		1,000 lux	295 lux	138 lux	567 lux

Make sense of data

Read and Talk
Students work together to make sense of the data gathered during their investigation.

Summary of Light Investigations			
Material	Transmits light?	Blocks light?	Reflects light?
clear plastic	yes	~~not sure~~ yes	not sure
foil	no	yes	yes
black felt	~~not sure~~ yes	yes	not sure
red felt	~~not sure~~ yes	yes	not sure
white felt	yes	yes	yes
waxed paper	yes	~~not sure~~ yes	yes
wood	no	yes	not sure

Write
Students create a visual representation that helps them make sense of the phenomenom.



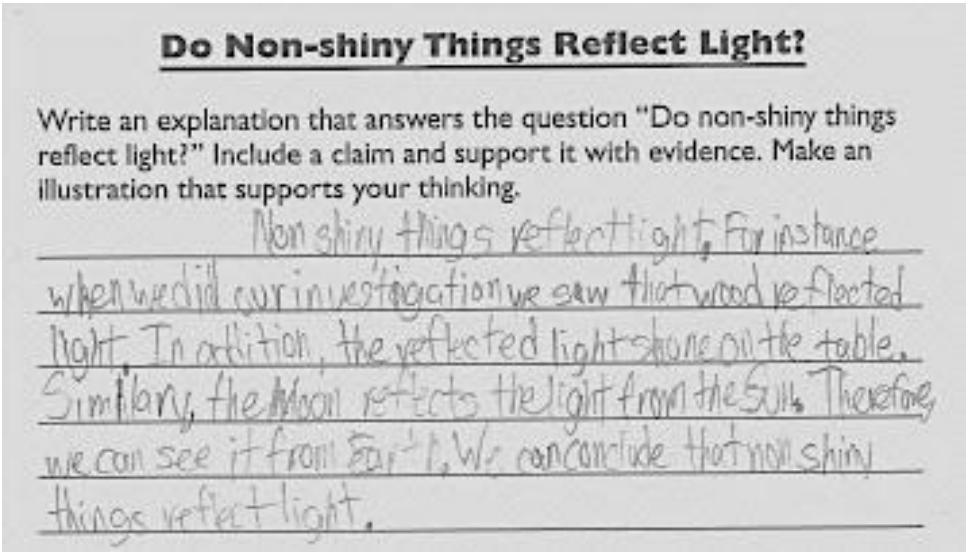
Discuss Results and Make Claims

Talk

Students participate in a discourse circle responding to the claim, “Materials of the same color absorb similar amounts of light”.

Write

Students work together to make claims about the reflection of light and support their claims with evidence.



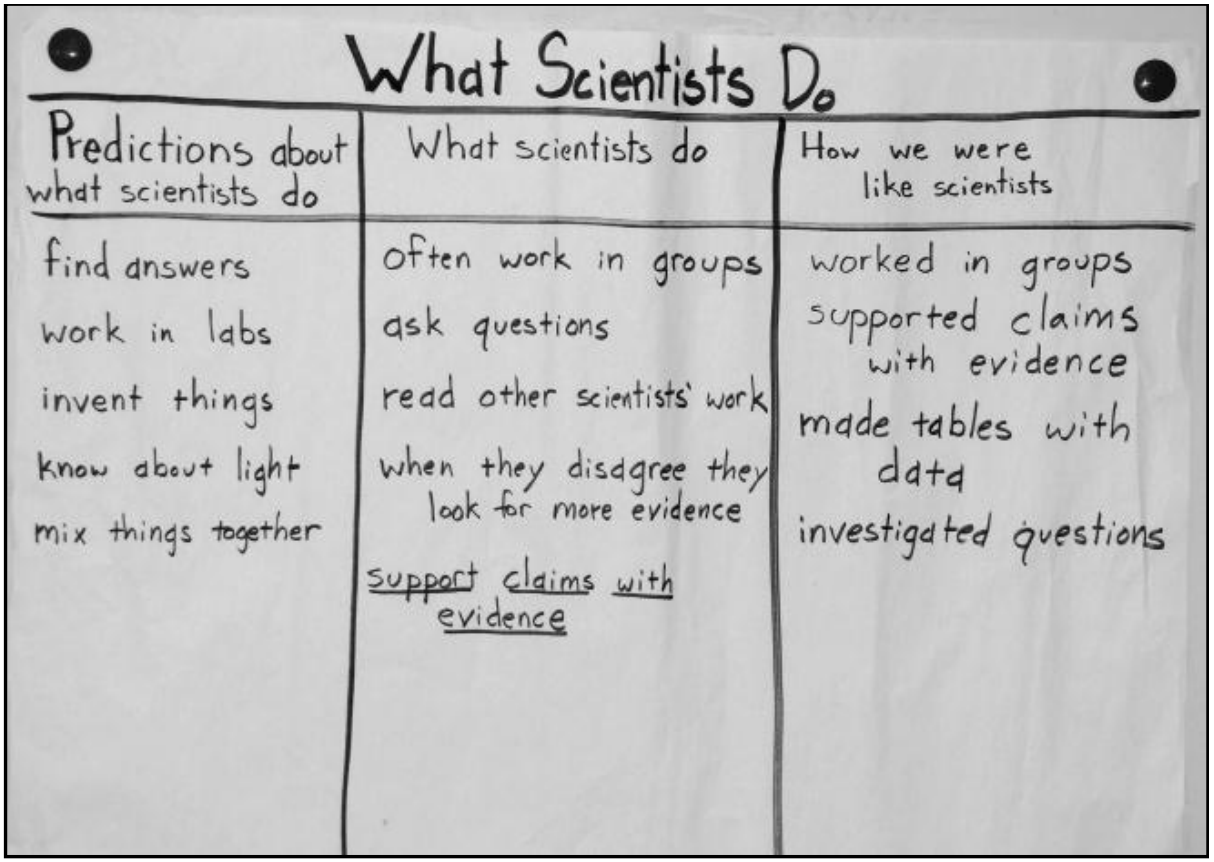
Do Non-shiny Things Reflect Light?

Write an explanation that answers the question "Do non-shiny things reflect light?" Include a claim and support it with evidence. Make an illustration that supports your thinking.

Non shiny things reflect light. For instance when we did our investigation we saw that wood reflected light. In addition, the reflected light shone on the table. Similarly, the Moon reflects the light from the Sun. Therefore we can see it from Earth. We can conclude that non shiny things reflect light.

Revisit Nature of Science

Write
Students connect their experience to the nature and practices of science.



What Scientists Do

Predictions about what scientists do	What scientists do	How we were like scientists
find answers	often work in groups	worked in groups
work in labs	ask questions	supported claims with evidence
invent things	read other scientists' work	made tables with data
know about light	when they disagree they look for more evidence	investigated questions
mix things together	support claims with evidence	

Reminding us of
Goal 3 of the NRC Report:
Successful K-12 STEM Education

Increase STEM literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines.

Language Demands of English Language Learners

Language Demands of Science			
Listening	*Reading*	*Speaking*	*Writing*
•Follow multi-step directions for an investigation	•Navigate reference books	•Participate in discussions in appropriate ways	•Write procedural and descriptive texts in appropriate genre
•Understand explanations without concrete examples	•Read to comprehend and interpret science texts	•Explain and/or present a process or findings	•Record extensive observations
•Understand Science Vocabulary	•Understand science vocabulary	•Demonstrate a range and control of science vocabulary	•Use precise vocabulary in writing products

Light Energy ELL Accommodations across 5 sessions

Session 2.1	Session 2.2	Session 2.3	Session 2..4	Session 2.5
Why Do Scientists Disagree? READING Reading with a Purpose p. 155	Which Materials Transmit Light? SCIENCE INQUIRY Affective Strategy p. 169	Writing about Transmission LITERACY DEVELOPMENT Writing Scaffold p. 185	Which Materials Block Light? SCIENCE INQUIRY Facilitating Science Language use p. 193 (85,37)	Making Sense of Shadows and Blocking SCIENCE/ LITERACY Promoting English Learners' Native Languages p. 213

Why Do Scientists Disagree?
(Session 2.1)

English Language Learners

Reading with a Purpose. To help English learners understand this book, some accommodations before, during, and after reading are needed.

Before reading, remind the students about idioms. Tell them many common expressions use words that have two meanings. On the board write the following idiomatic expressions: "spread out all over the world" (page 5), "disagreement moves science forward" (page 11), and "the father of science" (page 18). Have the students turn to these pages and read the phrases in context. Discuss and record the meaning of each idiom. Point out the ways in which *spread*, *forward*, and *father*—when used in these idioms—have meanings different from their usual meanings.

During reading, provide students with a sticky note and tell them to place it on a page where they had some trouble understanding the book.

After reading, discuss strategies for rereading difficult sections and explain that this is one way to help students understand difficult sections of text. With the class, choose one passage that many students found difficult. Guide them through the rereading process by having them discuss the meaning of the passage with a partner and then reread the passage slowly. When they finish reading, discuss the meaning of the passage as a group.

Before Reading:
Awareness of Idioms in *Why Do Scientists Disagree?*

From page 5

The scientific community is spread out all over the world. Still, all scientists are connected. They all want to learn more about how the world around them works.

From Page 11

Scientists often disagree. Some people think of disagreement as a bad thing, but it is very important in science. Disagreement moves science forward.

From page 18

Today, scientists all over the world remember Galileo. He was brave enough to disagree. He always supported his claims with evidence. Some people call Galileo "the father of science." They mean that he set a great example for other scientists to follow.

Instruction Builds:

from previous ELL note (Session 1.1)

English Language Learners

Idiomatic Expressions. To help English learners understand this book, some accommodation may be needed to help them understand idiomatic expressions. Before reading, discuss idiomatic expressions in general. Write on the board "Finishing my homework is a piece of cake." Tell the students this sentence contains a phrase that means something different from what you might think based on the words. In this case, the phrase does not mean the homework is made of cake! Ask the students if they think the sentence means that the homework is easy or hard. Write on the board these five idiomatic expressions found in the book: "light is creeping in"; "none, nada, zip, zilch"; "put the fire out"; "dive under your bed"; and "a smile crosses your face." Have students work in pairs to find and read the page where the idiom is found and figure out what is meant. As a class, discuss the meaning of each idiom.

Supporting the Development of Strategic Behavior

(Session 2.3)

English Language Learners

Writing Scaffold. English learners may need extra help writing scientific explanations. Provide them with sentence starters they can use in writing their evidence sentences. Caution them to think carefully about which starters to use for each sentence. You could write the following sentence starters on the board, or photocopy a sheet with the sentence starters for each student who needs them.

For example, _____ does transmit light.
For example, _____ does not transmit light.
I know this because _____ .
When I tested _____, I observed _____
In addition, _____ .
Finally, _____ .

Provide Additional Scaffolds for Language

(Session 2.4, adding to the chart started in 1.2)

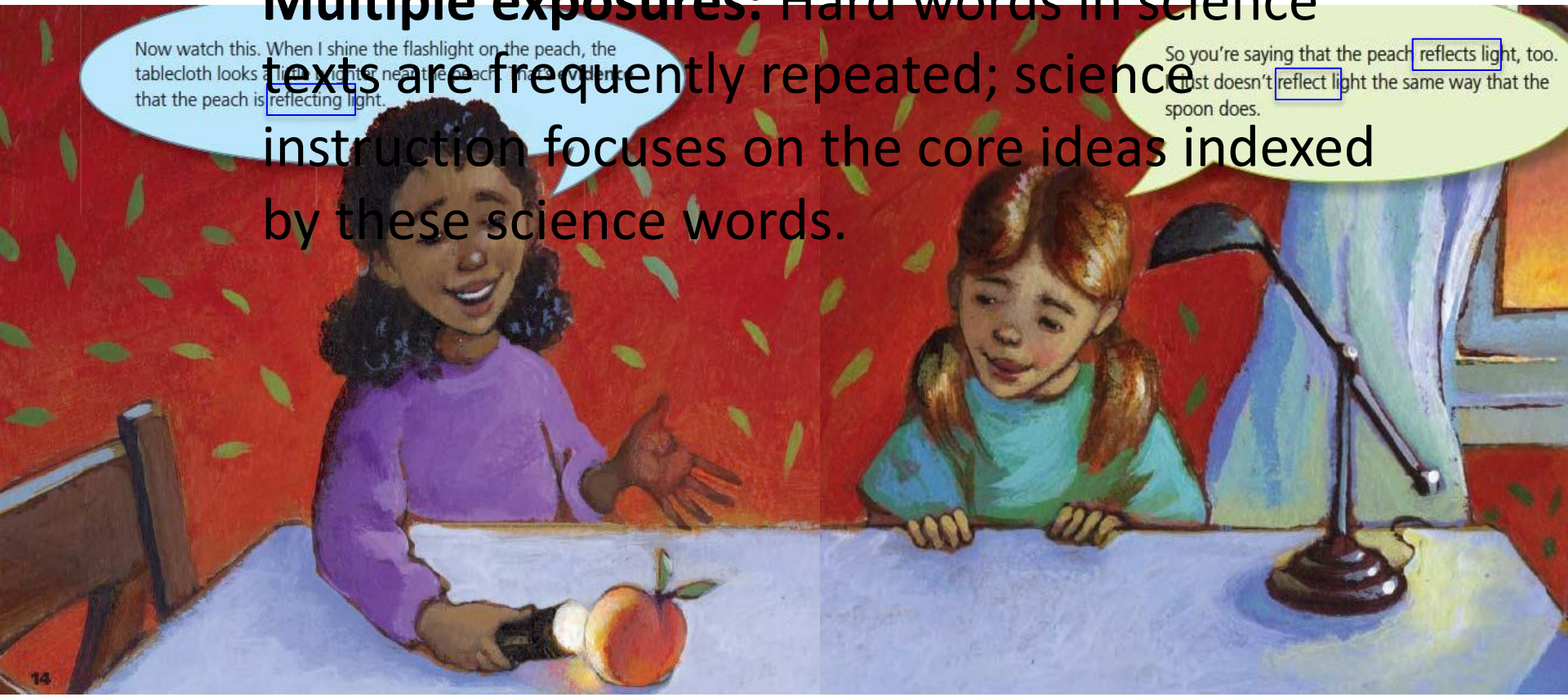
English Language Learners

Facilitating Science Language Use. If you started the Science/Everyday Words chart in earlier sessions, add the following word pairs to the appropriate section of the chart: *transmit/let through* and *material/stuff*. Tell the students that while these word pairs have similar meanings, *transmit* means to let all or part of something pass through and is often used when talking about letting through light, sound, or electricity. *Material* is the stuff that objects are made of, such as wood, plastic, or foil. Tell them that when talking or writing about science, they should use the science words instead of the everyday words to convey a more precise meaning.

Affordances of Vocabulary in Science

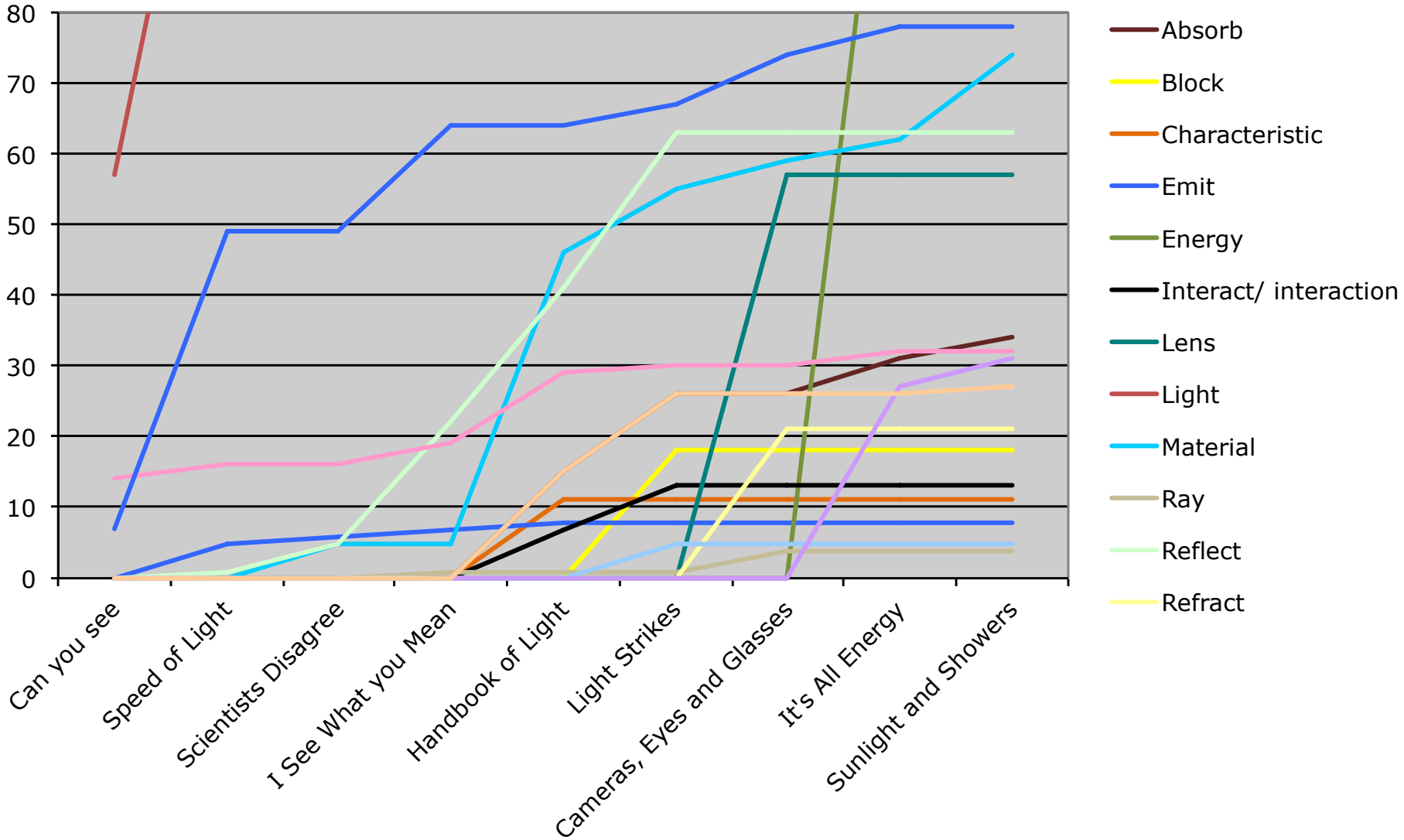
(from Cervetti & Bravo, 2008)

Multiple exposures: Hard words in science texts are frequently repeated; science instruction focuses on the core ideas indexed by these science words.

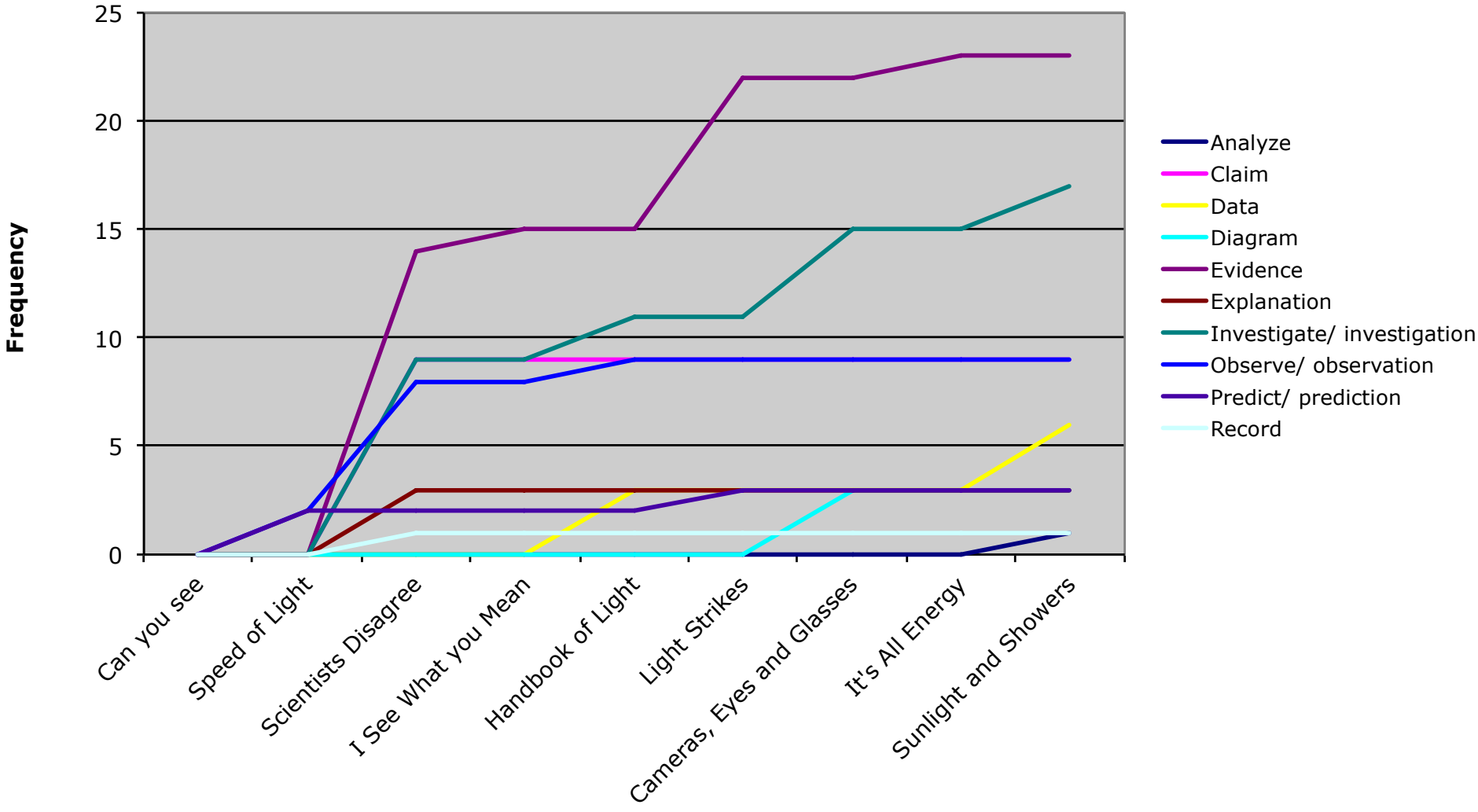


Key science term: **reflect**

Light Energy
Unit Words



Light Energy
Inquiry Words



Three "Gold Standard" Studies

- Grades 2/3 Soil Habitats & Shoreline Science
- Grades 3/4 Light Energy
- Grades 4/5 Planets and Moons

Several Sub Studies focused on English Language Learners

Positive Results Across the Board:

STUDENTS

- Outperform control students on measures of:
  - science conceptual knowledge
  - science vocabulary
- Perform equivalently or higher than control students on measures of:
  - science reading comprehension
  - science writing

TEACHERS

- Spend more time teaching science than control teachers
- Have more student-to-student talk in their classrooms
- Find value from the educative features of the Teacher's Guide

How does Seeds of Science help teachers learn?

Examples that follow are drawn from the Light Energy sessions we just experienced

(Sessions 2.1 – 2.4)

Treatment Version of Teachers Guide = LEFT + RIGHT PAGES

Comparison Version of Teachers Guide = LEFT PAGES ONLY

Example of a left-hand page from *Models of Matter*

Session summary
Including what students learn

Unit learning goals
Organized by the three *Seeds/Roots* science–literacy synergies

Materials/preparation
Where to find information describing the preparation necessary for each session

Time Frame
Pacing for each activity

Step-by-step instructions
Suggestions for teaching the session, including thoughtfully worded prompts

Science standards
Daily correlation "snapshots"

Example of a right-hand page from *Models of Matter*

Teaching Support and Considerations
See the following pages for more

Language of Science
Every right-hand page margin reminds you of important vocabulary to stress, with this session's important words and language of argumentation in bold type

Literacy Notes
Getting the most from the science–literacy connection

Science Notes
Background information on the session's topic

Literacy standards
Daily correlation "snapshots"

LEFT HAND PAGE

Step-by-step instructions

RIGHT HAND PAGE

Educative Curriculum Features

YEAR ONE

- 58 4th and 5th grade Teachers with high % of English learners

- Randomly assigned to teach either the treatment version or the comparison version of *Planets and Moons*
- Developed, administered and refined measures

YEAR TWO

- Invited 16 high implementers for second implementation of *Planets and Moons*
- Administered revised measures

6 treatment teachers

10 control teachers

Figure 2.

Trajectories in Use of Strategies for ELL Across Five Observations by Treatment Group

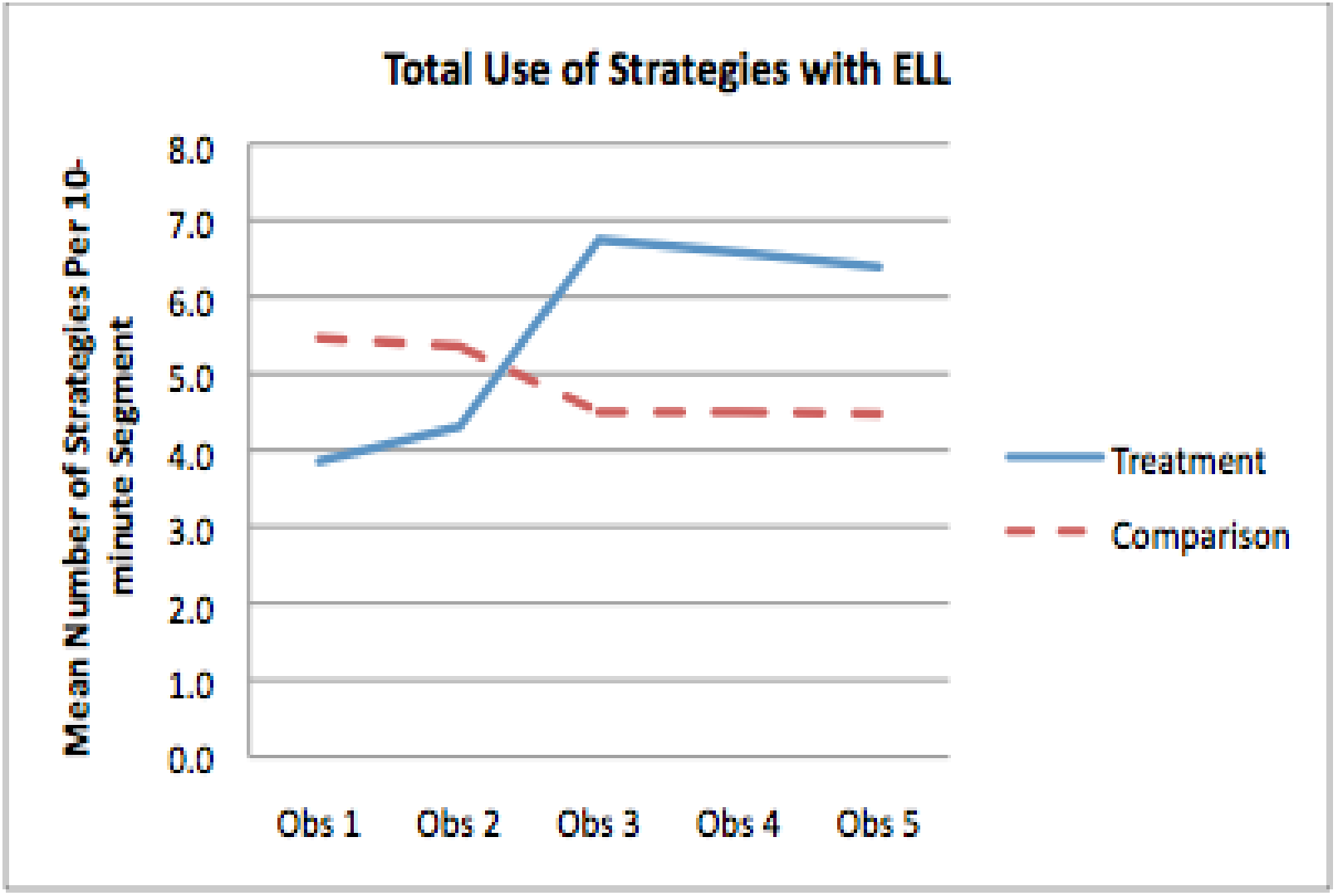


Figure 3

Mean Observed Use of Different Strategies for ELL Across Five Observations

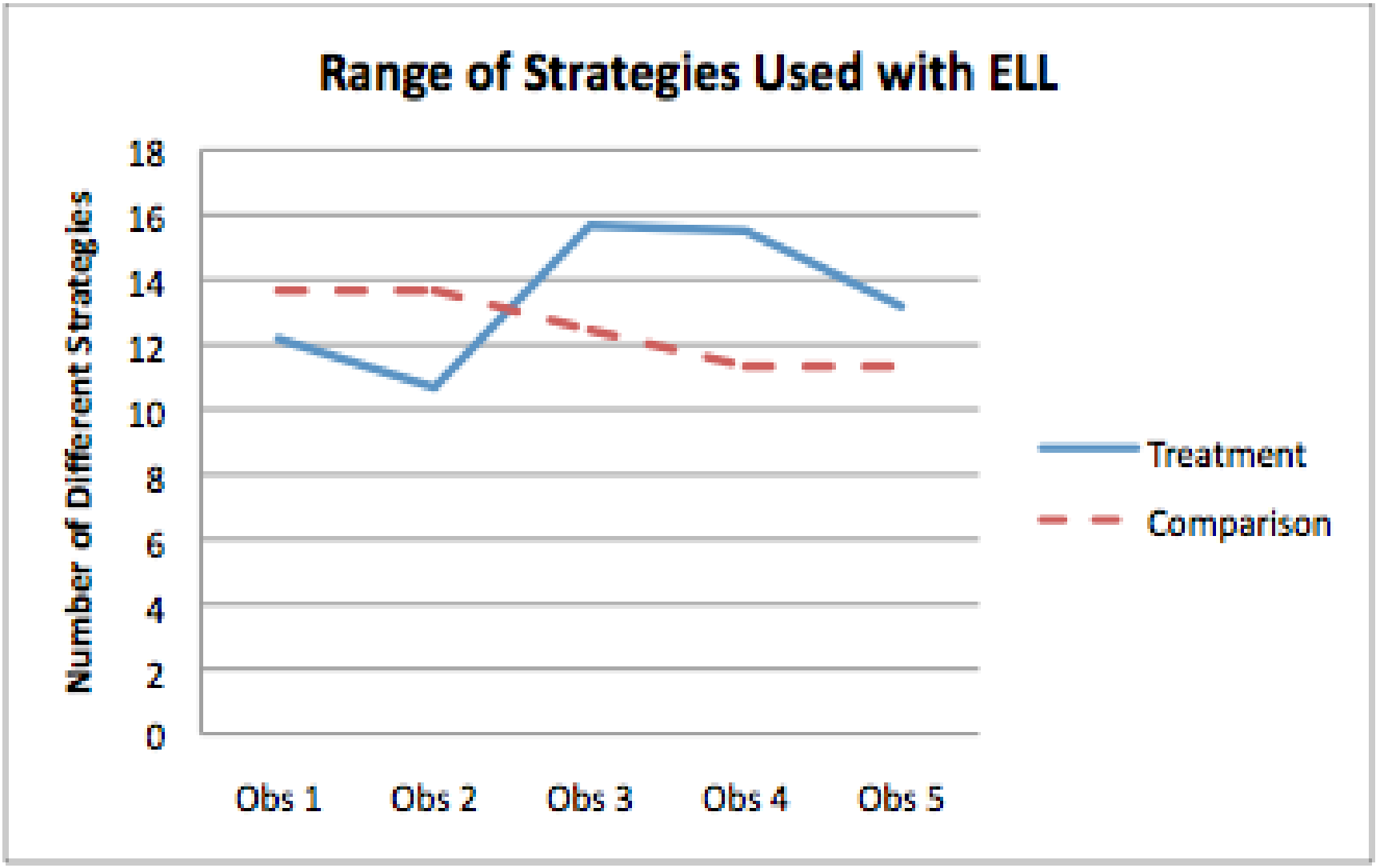


Figure 4

Mean Number of ELL Strategies Per Segment by Teacher, Treatment Group

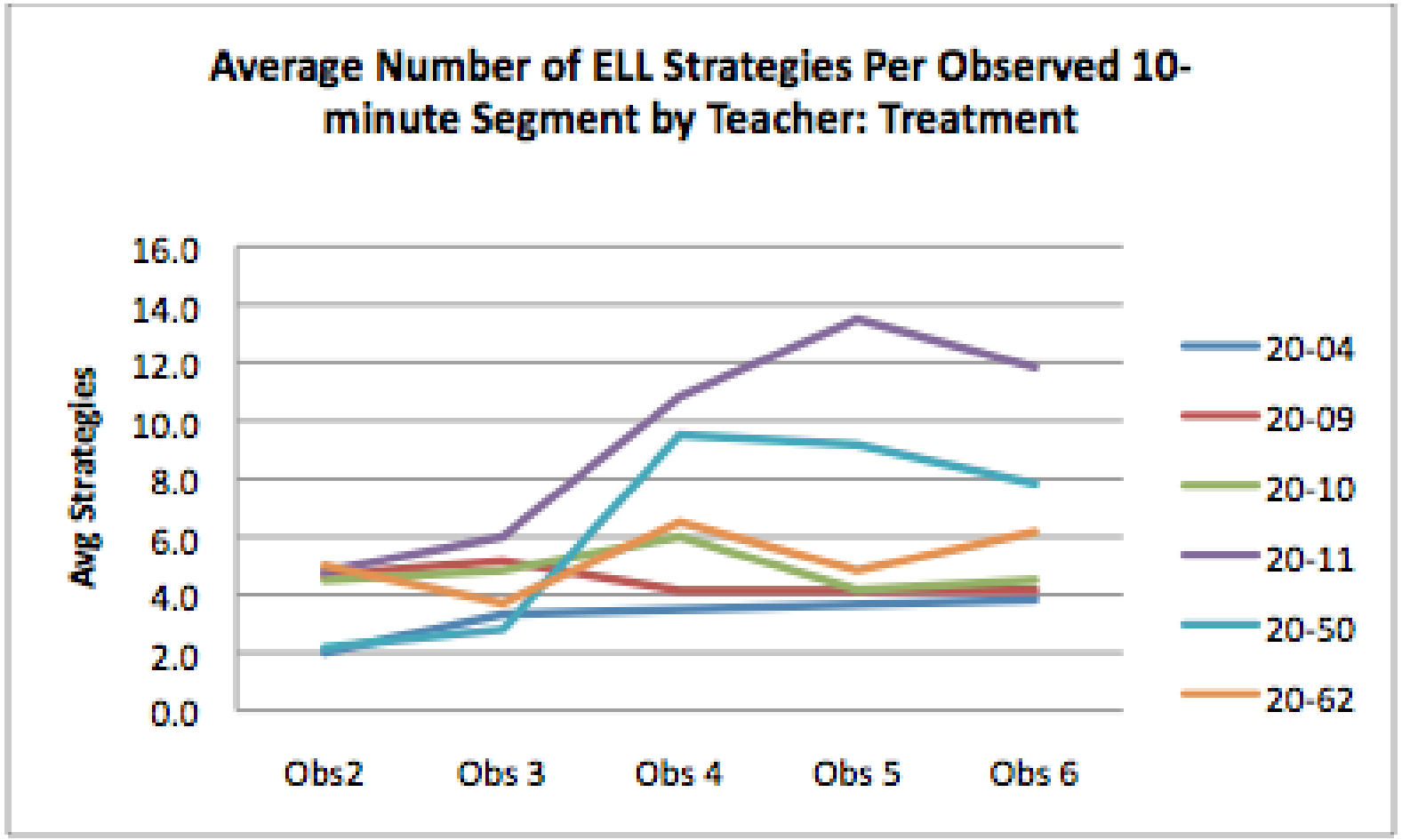
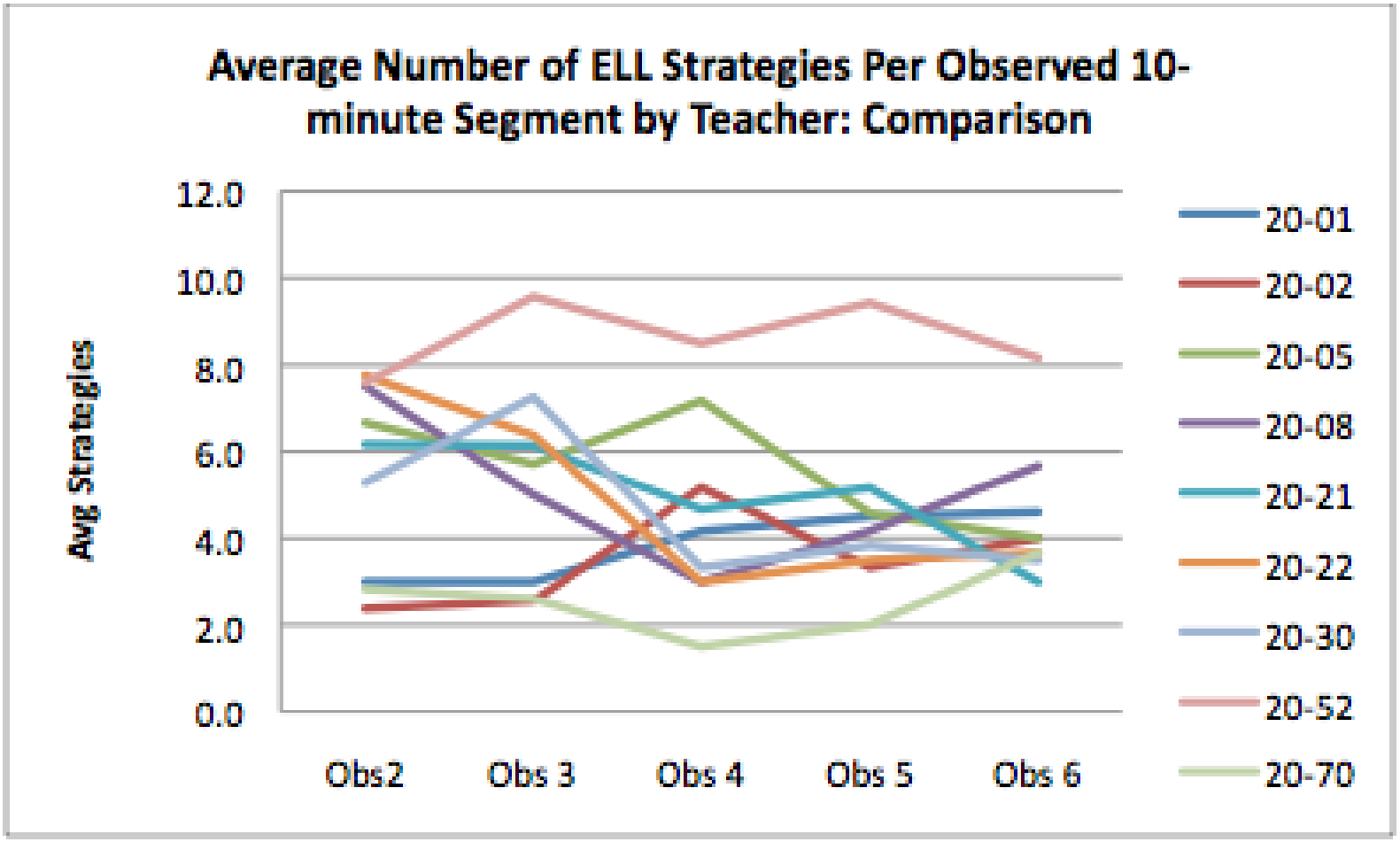


Figure 5

Mean Number of ELL Strategies Per Segment by Teacher, Comparison Group

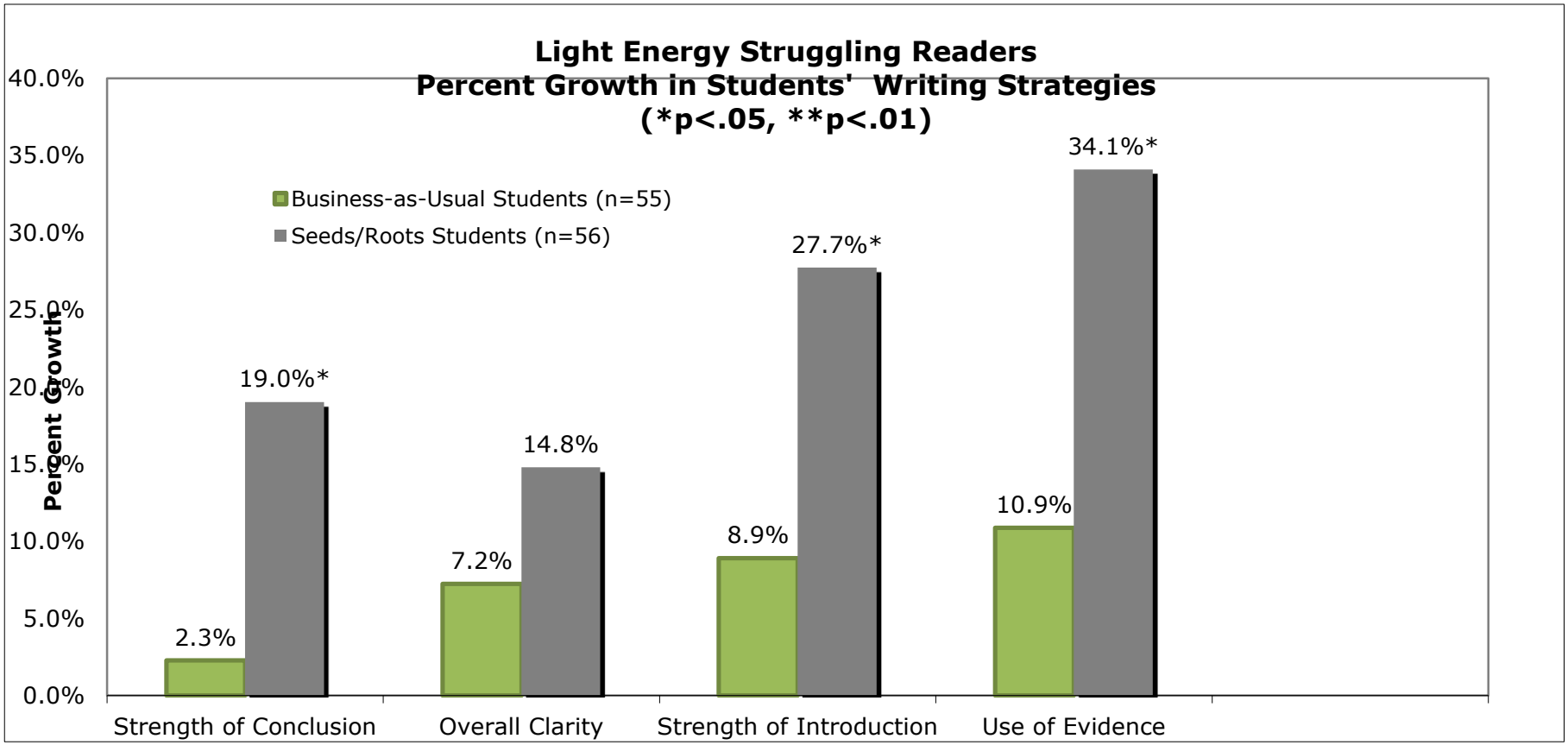


Advantage for ELL Students:

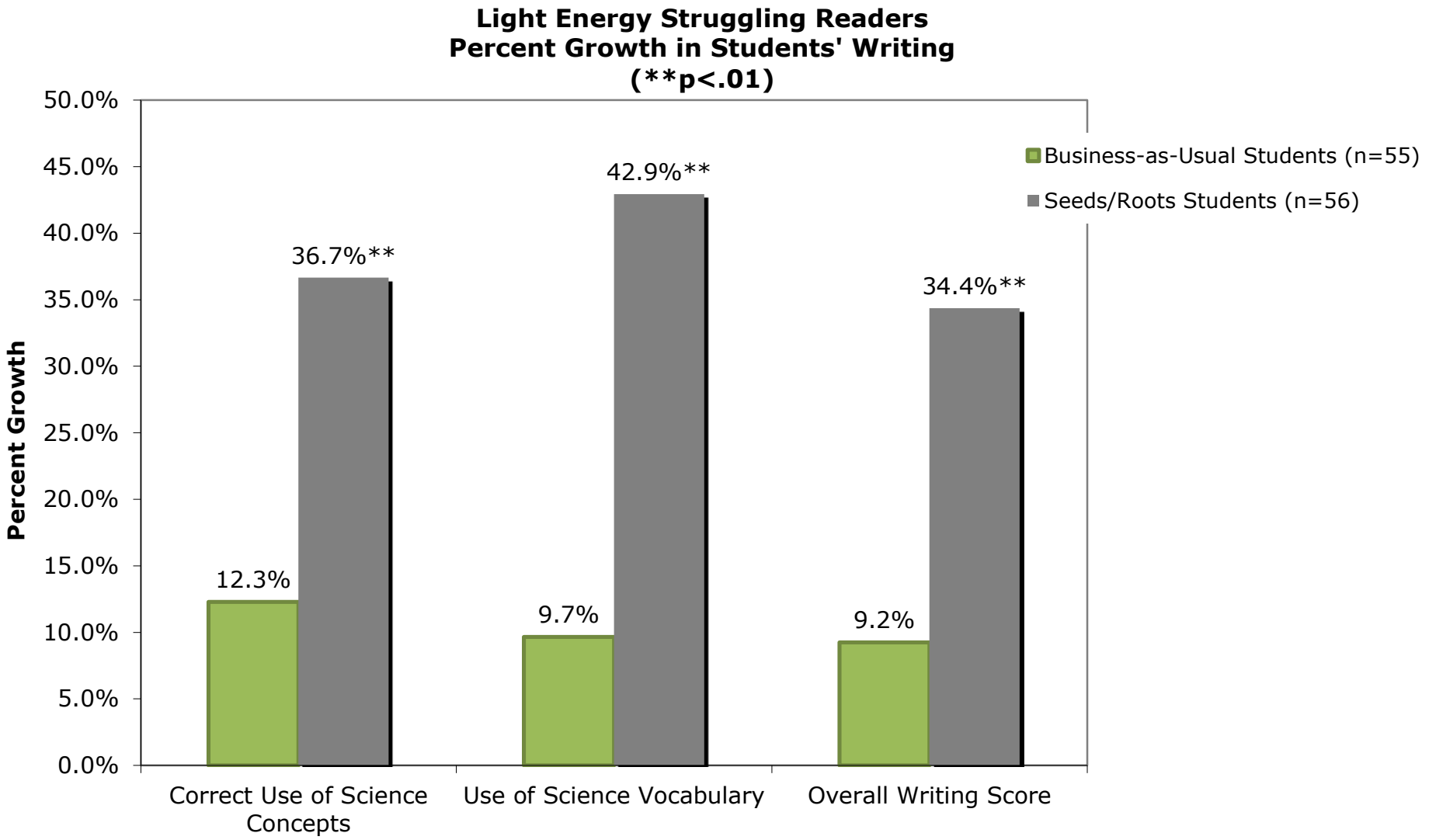
- In two different studies, English language learners (ELL) outperform ELL control students on measures of:
  - science conceptual knowledge
  - science vocabulary

(Bravo and Cervetti, 2011; Duesbury, Werblow and Twyman, 2011)

Subset of students: Struggling Readers



Struggling Readers, continued



Pre-test

Name Javier Date 6/28/16

Science Writing

What do you know about forces? When you write your answer, be sure to name, describe, and give examples of at least two forces.

I do Not Know What a force is but in think it is like a Person forces Someone to do something.

(1)

Name Javier Date 7/28/10

Post

Science Writing

What do you know about forces? When you write your answer, be sure to name, describe, and give examples of at least two forces.

(4)

I know that there are 3 diffrent kinds of forces there are gravity, Magnitic force, and electrostatic force. Gravity Pulls stuf to earth, Magnetic force attracts and repels, electrostatic sticks 2 things A Magnet sticking to Iron is a exaple of a Magnetic force. A kid kicking a ball is a example of gravity. Electrostatic force needs a object charged.

Table Interaction

Working with your tablemates, correlate the
English Language Learners Considerations
to the
Four Principles that Make Science Accessible for ELL's.

Discussion Topic:
How can your work benefit from the
work shared here?

How can/will your office help meet the language demands of science for all learners?

What solutions does SEEDS offer and for whom?

- Success for English Language Learners and other struggling readers and writers. Who?
  - Districts with high percentages of ELL students
    Holyoke, MA
    Fresno, CA
    Minneapolis, MN
  - English Language Development
    Santa Barbara, CA
  - Program improvement schools who are looking to provide more ELA instructional minutes
    Vineland, NJ

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How do *Seeds/Roots* students compare?

SEEDS makes more of a difference

Type of Intervention	Average Effect Size
Participation of elementary students in one 8-10 week SEEDS unit	.61
Computer-based instruction	.45
Cooperative learning with elementary students	.3
Use of inquiry methods in science	.3
Class size reduction	.2