New Standards Bring New Expectations: A Look at the Convergence of Science and Literacy across Grades K-12

Stem Smart:
Lessons Learned from Successful Schools

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Disclaimer

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Two extremes

Hands-on-dominated Science

(mostly doing and talking)

Text-dominated Science

(mostly reading and writing)

Plan for this afternoon

- Share expectations of new standards with regard to the convergence of science and literacy
- Focus in on productive roles for text in effective science teaching and learning
  - Example from EDC
  - Example from the Hall
- Q&A

Goals

- Prompt thinking about the opportunities and challenges of employing text in an NGSS era
- Provide information about the findings from several NSF-funded research and development projects
- Provide usable strategies for incorporating text in your science program

Convergence!

- Common Core States Standards for English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects
- The National Research Council's *A Framework for K-12 Science Education* led to:
- Next Generation Science Standards (NGSS)

A Broader Definition of Science and Engineering Practices

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

Inquire like a scientist.

Think like a scientist.

Quantify like a scientist.

Read like a scientist.

Talk like a scientist.

Write like a scientist.

Argue like a scientist.

Convergence!

from science inquiry only		to a broad view of science practices

Balance that is authentic to science

Learning through text and experiences

Reading, interpreting, and producing text are fundamental practices of science in particular, and they constitute at least half of engineers' and scientists' total working time.

NRC Framework for K-12 Science Education

Read like a scientist

Jacqueline Barber
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HALL OF SCIENCE
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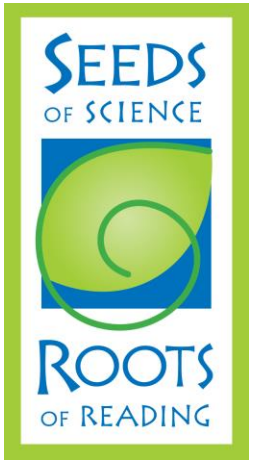
The Learning Design Group



AmplifyScience.

www.scienceandliteracy.org
www.learningdesigngroup.org
www.argumentationtoolkit.org
www.sciencearguments.weebly.com

We set out to investigate a model of science instruction that:

Includes a balance of learning modalities
DO-TALK-READ-WRITE

Employs reading and writing in ways that are authentic to science

Provides students (and teachers) with explicit instruction in literacy skills and strategies

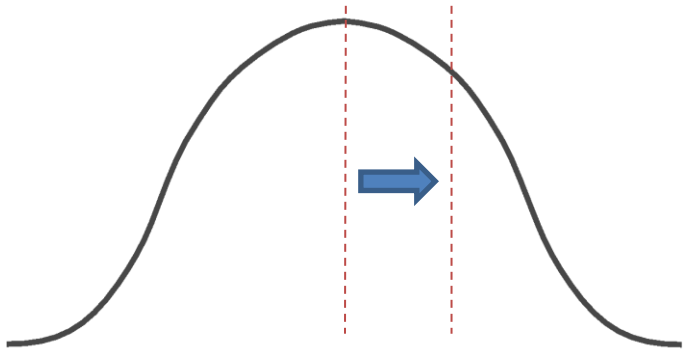
Three Gold Standard Studies

- UCLA's CRESST
- 89 classrooms.
- Random assignment to treatment and comparison groups
- Comparison group: content-comparable, business-as-usual

A Better Way to Learn Science

- Our combined science literacy program can elevate students previously scoring the 50th percentile in science into the top third of their peers.

Average effect size: 0.61 (Cohen's D)



Gains in Literacy as well as Science

Positive Results Across the Board:

STUDENTS

Out-perform control students on measures of:

- science conceptual knowledge
- science vocabulary

Perform equivalently or higher than control students on measures of:

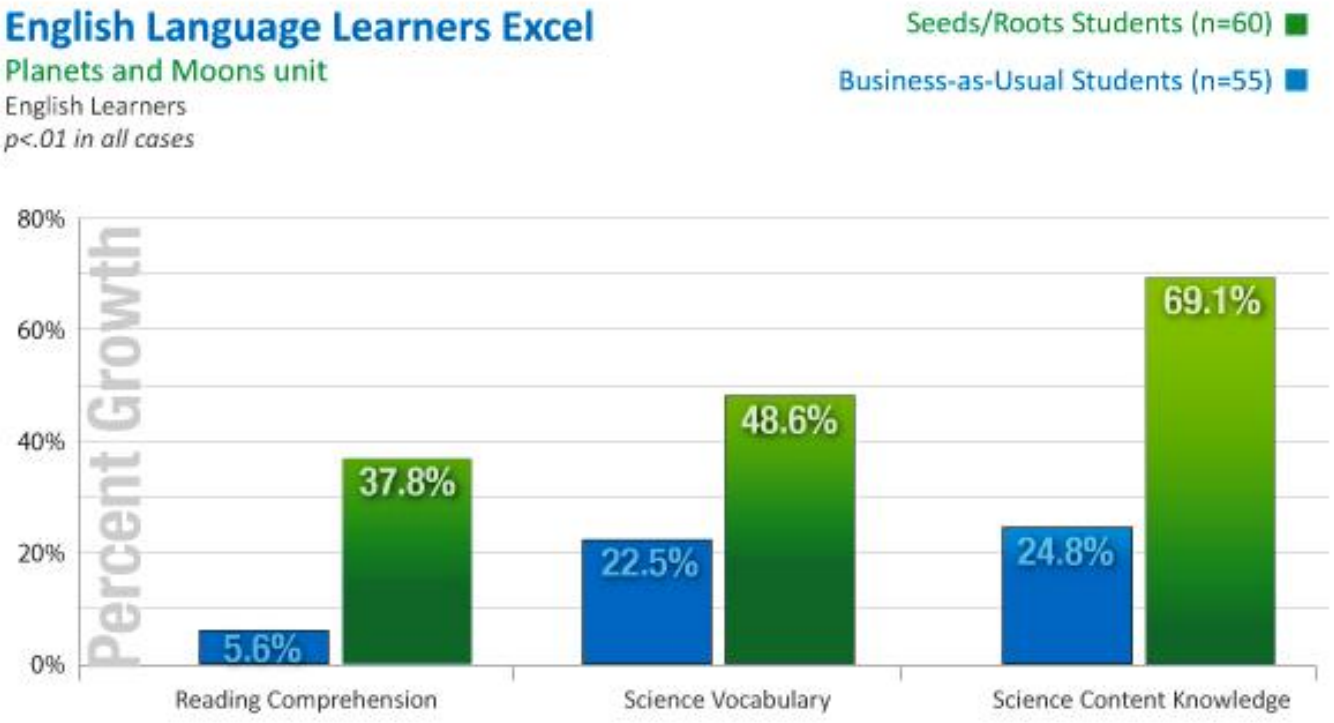
- science reading comprehension
- science writing

TEACHERS

Spend more time teaching science than control teachers

Have more student-to-student talk in their classrooms

Advantage Holds for English Learners



Our Basic Approach to Literacy-Rich Science Learning

DO	**TALK**
READ	**WRITE**

Doing Science

Need a Question:
What do Magnets Attract?

DO	**TALK**
READ	**WRITE**

Our Approach

Gather evidence from firsthand and secondhand sources

DO: Search for Evidence through Experience

READ: Search for Evidence in Text

ct	Kind of metal	Does a mag attract it?
can	aluminum	no
r clip	steel (mostly made of iron)	yes
y	copper and zinc	no
	aluminum	no
	iron	yes
	zinc and iron	yes
n's necklace	silver	no
's ring	gold	no
l wool	steel (mostly made of iron)	yes
in kitchen	steel (mostly made of iron)	no
under sink	copper	no
ng pan	iron	yes
lamp	brass (made of copper and zinc)	no

Our Approach

Written + Oral Discourse
(for a purpose)

TALK: Discuss claims

WRITE: Write explanations

As Opposed to “Doing School”

DO: Students investigate with magnets

READ: Students read about magnets

WRITE: Students write what they learned about magnets

Our Approach

Engage in the practices of science

DO	**TALK**
READ	**WRITE**

Have students **read**, **write**, and engage in **talk** as practices of science

Read like a scientist

Write like a scientist

Discuss like a scientist

Argue like a scientist

Practice 1:
Ask questions

Practice 4:
Analyze and
interpret data

Practice 5:
Use mathematics
computational thinking

Read like a scientist

Practice 6:
Construct
explanations

Practice 7:
Engage in argument
from evidence

Practice 8:
Obtain and evaluate
information

3 Important Shifts

Read like a student → Read like a scientist

- Goal for reading
- Approach to reading
- Purpose for reading

Different outlook about the goal of reading

How do students view reading?

- With the goal of absorbing what the text says

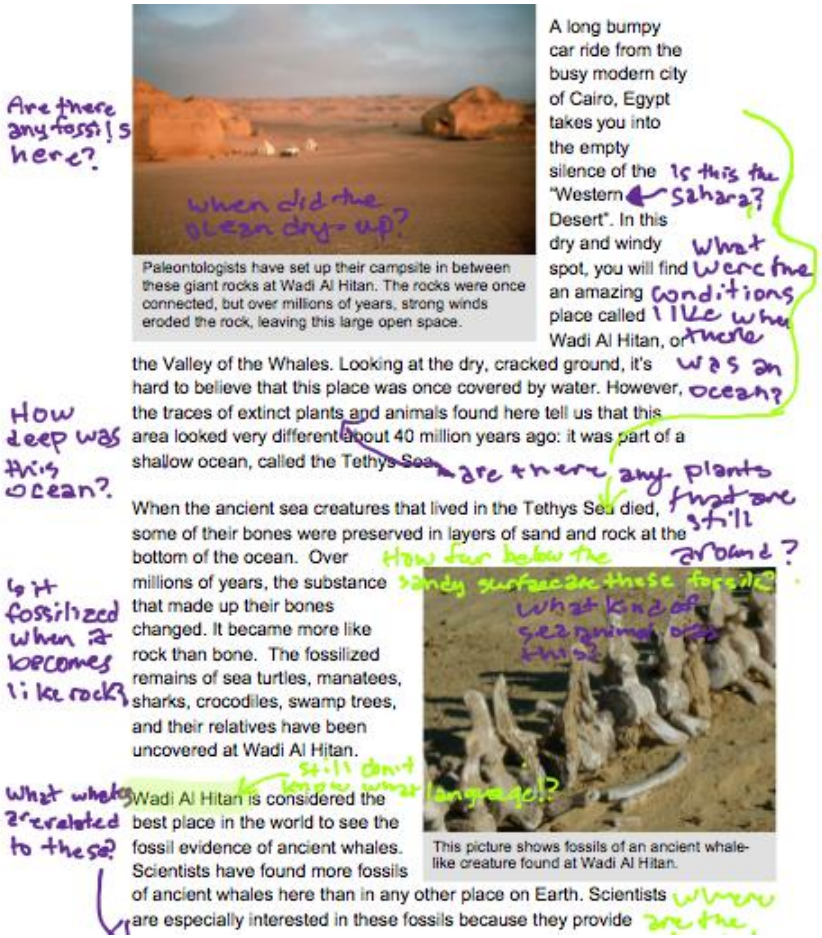
How do scientists view reading?

- As an act of inquiry

Different outlook about the goal of reading

How do scientists view reading?

- As an act of inquiry



What language is this?

Wadi Al Hitan (Valley of the Whales)

Paleontologists have set up their campsite in between these giant rocks at Wadi Al Hitan. The rocks were once connected, but over millions of years, strong winds eroded the rock, leaving this large open space.

Are there any fossils here?

A long bumpy car ride from the busy modern city of Cairo, Egypt takes you into the empty silence of the "Western Desert". In this dry and windy spot, you will find an amazing place called Wadi Al Hitan, or the Valley of the Whales. Looking at the dry, cracked ground, it's hard to believe that this place was once covered by water. However, the traces of extinct plants and animals found here tell us that this area looked very different about 40 million years ago: it was part of a shallow ocean, called the Tethys Sea.

Is this the Sahara?

What were the conditions like when there was an ocean?

How deep was this ocean?

are there any plants that are still around?

When the ancient sea creatures that lived in the Tethys Sea died, some of their bones were preserved in layers of sand and rock at the bottom of the ocean. Over millions of years, the substance that made up their bones changed. It became more like rock than bone. The fossilized remains of sea turtles, manatees, sharks, crocodiles, swamp trees, and their relatives have been

How far below the sandy surface are these fossils?

What kind of sea animal is this?

Is it fossilized when it becomes like rock?

Supports for learning how to read like a scientist

Provide explicit instruction in:

- how to have a conversation with the text
- comprehension strategies, such as asking questions making inferences, setting a goal for reading, making predictions

Our Approach

Don't Assume

DO	**TALK**
READ	**WRITE**

That students know how to

read science text, **write** science text,

and engage in science **talk**

Different approaches to reading

How do students read?

- From beginning to end

How do scientists read?

- Skip around
- Use headings
- Read captions
- Compare text descriptions to visual representations
- Check their understanding

Different approaches to reading

How scientists read

- Skip around

Contents

My Sister 4

Explanation 1: Magnetic Force 6

Explanation 2: Magnetic Poles. 9

Explanation 3: What Magnets Attract 14

My Sister's Notebook 19

Inventing with Magnets 22

Glossary 23

Different approaches to reading

How scientists read

- Compare text descriptions to visual representations

Poison oozes from a rough-skinned newt's skin.

Supports for learning how to read like a scientist

Provide explicit instruction in:

- use of text features
- interpreting visual representations
- Comparing text and visual representations

Different purposes for reading

Why do students read?

- Because the teacher assigned a reading
- To learn information

Why do scientists read?

- To situate their research
- To interpret others' data and critique their findings
- To find specific information to support their own investigations
- To learn about others' procedures and experiments
- To learn what other scientists are learning

Opportunities for students to engage in reading for multiple purposes

Why Scientists Read

- To situate their research
- To interpret others' data and critique their findings
- To find specific information to support their own investigations
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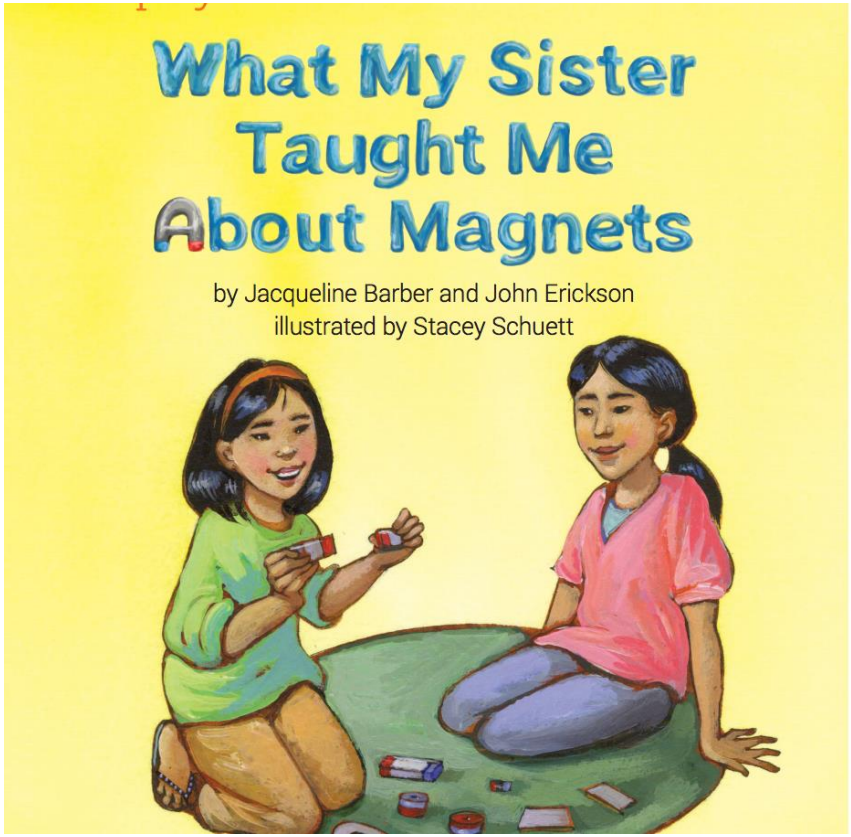


Why do some metals attract magnets and some do not?

Why Scientists Read

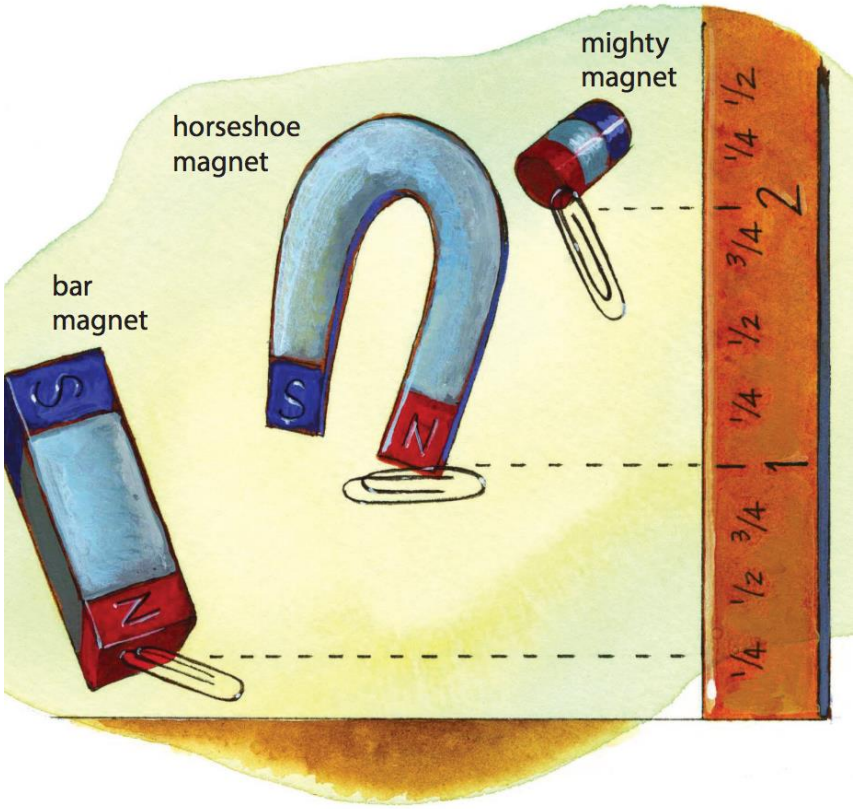
- To interpret others' data and critique their findings
- To find specific information to support their own investigations

Object	Kind of metal	Does a magne attract it?
Juice can	aluminum	no
Paper clip	steel (mostly made of iron)	yes
Penny	copper and zinc	no
Foil	aluminum	no
Nail	iron	yes
Nail	zinc and iron	yes
Mom's necklace	silver	no
Dad's ring	gold	no
Steel wool	steel (mostly made of iron)	yes
Sink in kitchen	steel (mostly made of iron)	no
Pipe under sink	copper	no
Frying pan	iron	yes
Tall lamp	brass (made of copper and zinc)	no

Do all magnets have the same magnetic force?

Why Scientists Read

- To learn about others' procedures and experiments



Models Scientific Explanations

Why Scientists Read

- To learn what other scientists are learning

"So?" I said. "What's your explanation?"

She said, "I think the horseshoe magnet is stronger than the bar magnet. It can pull with more magnetic force. A stronger magnet will pull the paper clip up from farther away."

Then she gave me a big smile. She showed me a little magnet called a mighty magnet. She held it over the paper clip. The paper clip jumped almost two inches in the air to reach the strong mighty magnet!

Connects to the importance of magnet investigations in the world outside the classroom

Why Scientists Read

- To situate their research

Inventing with Magnets

Supports for learning how to read like a scientist

- Frame instruction as questions to figure out
- Provide texts that:
  - introduce secondhand (text) sources of evidence that complement the evidence students are gathering from firsthand sources
  - are closely aligned to what students are trying to figure out
  - enable students to read for the variety of purposes that scientists read

A Broader Definition of Science and Engineering Practices

1. Asking questions
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3 Important Shifts

Read like a student → Read like a scientist

- Goal for reading
- Approach to reading
- Purpose for reading

3 Important Factors

- The role of text
- How students interact with text
- The nature of the text

Disciplinary Literacy
Strategy Guides for Grades K-5

- Gathering Information from Science Texts
- Interpreting Visual Representations
- Teaching About Multiple Meaning words
- Teaching Concept Mapping
- Teaching Text Structure
- Using Anticipation Guides
- Using Visual Evidence to Make Inferences

Disciplinary Literacy
Strategy Guides for Grades 6-8

- Reading Arguments
- Understanding the Role of Relevant Evidence in Supporting a Claim
- Using the Reasoning Tool to Develop a Strong Written Argument
- Practicing Oral Discourse Skills

http://scienceargumentsweebly.com/teaching-strategies.html

www.scienceandliteracy.org
www.learningdesigngroup.org
www.argumentationtoolkit.org
www.sciencearguments.weebly.com

jbarber@berkeley.edu

Learning Science through Narrative Nonfiction

EDC Learning transforms lives.

Making the Case for Reading in High School Science – in Learning

- Reading for comprehension is fundamental to both the doing of science and the learning of science.
- Both require the ability to derive meaning from scientific text, to evaluate the scientific validity of the information and to integrate related information from different sources
- The ability to read science-related text addresses one of the major goals of science education – a science literate citizenry

Making the Case for Reading in High School Science - Convergence

Common Core States Standards for English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects

- Integrate and evaluate multiple sources of information in order to address a question or solve a problem.
- Evaluate the the information in a science or technical text, and validating with other sources of information.
- Synthesize information from a range of sources

Next Generation Science Standards (NGSS) Practices

8. Obtaining, evaluating, and communicating information

Making the Case for Reading in High School Science – The Data

Reading Between the Lines: What the ACT Reveals About College Readiness in Reading

<u>The problem</u>

- Only about half of our nation's ACT-tested high school students are ready for college-level reading.

- More students are on track to being ready for college-level reading in eighth and tenth grade than are actually ready by the time they reach twelfth grade.

- The clearest differentiator between students who are college ready and students who are not is the ability to comprehend complex texts

<u>One recommendation</u>

Strengthen reading instruction in all high school courses by incorporating complex reading materials into all course content.

The Challenges of Science Text at the Secondary Level

Reading of science text is often difficult for many students (and, speaking as a former research scientist, also for many scientists)

- Jargon/vocabulary often unfamiliar or differs in meaning from the vernacular
- Science text must be read to extract information accurately;
- Science texts are multimodal requiring integration of the written word, diagrams, chats, tables, equations, symbols etc.
- Often science text is mind-numbingly boring
- Supporting reading for comprehension may be difficult for secondary school teachers

Addressing the Challenge with Narrative Nonfiction

Narrative nonfiction has all the is a style of writing that has many of the same elements of a story or novel

- clear, well-developed characters
- story is told using scenes that follow a narrative arc
- an identifiable theme
- use of literacy devices such as imagery, symbolism, and metaphor
- Engaging and accessible but can still be complex
- Factual content must be accurate and verifiable

Narrative Nonfiction Can Be: Story

"Storytelling is not something we just happen to do. It is something we virtually have to do if we want to remember anything at all."

E.O. Wilson
The Power of Story American Educator , v26 n1 p8-11 (2002)

Stories can

- provide a framework to help organize and anchor concepts and content;
- engage both intellectually and emotionally, thus motivating students to learn the concepts involved in the story, and can create a desire to "dig deeper" into the ideas;
- can enhance assimilation of understandings into long term memory by association with the story

Narrative Nonfiction Can Be: Informational Text

Informational text can be written to provide content and conceptual coherency in a style that is accessible and engaging while retaining complexity and scientific accuracy and rigor

Using Narrative Nonfiction in the Classroom – An Example

Start with a Story

- Engage
- Show relevancy
- Pose a challenge
- Provide motivation

Informational Text

- Provide concepts and content to address the challenge
- Develop ability to extract relevant information

Application

- Deeper learning – transfer to a new situation

Simple Change, Unintended Consequences: Exploring Ecosystems

from Biology: Concepts and Practices

Goals for Student Understanding

- Ecosystems are interconnected by biological, physical, and chemical processes.
- Interactions among the biotic components and between the biotic and abiotic components define the features of an ecosystem.
- These interactions generate complex ecosystems that are stable over time but demonstrate cyclic fluctuations around equilibrium.
- Even simple changes in the ecosystem, whether natural or human-made, can cause major changes in the interactions in that ecosystem.

What's the Story?

Monsters of the Not So Deep—The Story of Lake Victoria

The story describes the ecology of Lake Victoria and the consequences to the lake as a result of the introduction of the Nile perch. This reading provides students with a vivid example of how a single change to an ecosystem can have dramatic and devastating consequences.

- Introduces concepts in ecosystems and the Law of Unintended Consequences
- Sets the stage for a challenge:

The Challenge

Students analyze a scenario in which an ecosystem is disturbed by an event. Students apply their understandings about the ecosystems to describe the impact of the change on the ecosystem and propose ways that the impact might be reversed.

Gathering and Synthesizing Information from Activities and Informational Text

ACTIVITY : Life Underfoot, Life Under Water

An exploratory investigation in which students analyze the biotic and abiotic components of a soil or water sample

READING: Living in the System

This reading provides information students need to address the challenge, including fundamental content about ecosystems and the interdependencies within them

Addressing the Challenge Applying Understandings

Scenario

- Mosquitoes: Can't Live With 'em, Can't Live Without 'em
- Invasion of the Night Crawlers
- Bright Lights, Night Lights (or Lightbulb, Mon Amour)
- Snakes on a Plane
- Stinging in the Rain
- Burning 'Glades

Poster Demonstrating Synthesis and Communication

Students

- prepare a poster containing information about the change that occurred, the consequences of a single event , and suggestions for reversing the consequences
- view other groups' posters and take notes in preparation for a class discussion
- discuss own conclusions and solutions
- compare own ecosystem to others

.

Supports for Reading

Supporting reading for comprehension may be more difficult for secondary school teachers than elementary teachers who have expertise in teaching reading and writing

Recommendation in ACT college readiness report

Provide high school teachers with guidance and support to strengthen reading instruction

This can be done in preservice, inservice, and in educative curriculum that supports both teacher and student learning

Examples of Reading Strategies For Teachers

Teaching Strategies: Reading for Comprehension

For some students, this reading may be a review and reminder of many of the concepts they studied in middle school. For other students, the material may be new. Students are asked to Think About It within the reading. Inform them that this is a strategy designed to help them extract information by taking a breather and forming meaning of what they just read. Encourage them to write their responses and to jot down new vocabulary with their definitions in their notebooks. If you elect to have students read this in class, you may want to have a guided reading experience in which you have them stop after each paragraph and review the important points in what they have just read.

Examples of Reading Strategies For Teachers

Teaching Strategies: The Art and Skill of Skimming

The biographies of the scientists involve a great deal of reading, far too much for students to take in with a careful reading at this point. The goal of skimming the biographies is to see if anything jumps out at them as especially interesting. The skill of skimming a reading may be one students are not familiar with. When skimming, a reader looks for key words or phrases as their eyes pass over the page. Students may want to glance over the biographies and the science experiments, and if anything strikes them, go back and read that section more carefully before making choices about the scientist they may want to investigate further.

Example of Reading Strategies for Students

Student Note: *A word about words. Learning biology is, in part, about learning the language of biology. As you proceed through this course, you may feel somewhat overwhelmed by all the new vocabulary. A glossary is provided but you may want to create your own glossary in your notebook. As you come across new vocabulary, write the word in your glossary and the definition in your own words. These words are important because they will help you communicate ideas to your classmates and teacher. They might also help you see the world differently. For example, when you understand the meaning of the term biotic community, you may start to see more in a meadow, park, or tree trunk than you did before.*

Final Word(s)

In his essay “The Power of Story” E.O. Wilson proposes that science can be taught effectively through story. He states that the human brain functions by constructing narrative and that the presentation of complicated, essential science to a broad audience can be achieved through narrative and telling the science as a story.

He identifies the split between an educated person’s ability to understand science and the scientist’s ability to communicate scientific understandings in clear language as the “central challenge of education in the 21st century”. Narrative nonfiction in science writing and curriculum offers a powerful approach to bridging that split and educating students about the wonders of the natural world.