DATA *Nuggets* in the Classroom

Little Nuggets Can Do Great Things

Goals for this session

- Discuss the challenges faced by science teachers to increase quantitative reasoning skills in their students
- Introduce Data Nuggets as a potential solution
- Review CER and how to use it in the classroom

What is Quantitative Reasoning?

What is Quantitative Reasoning?

Discuss in small groups:

- What is your definition of quantitative reasoning?
- What are students expected to do?
- How do you teach QR in your classroom?

What is Quantitative Reasoning?

- A way of viewing the world through "mathematical eyes" and approaching every day problems with confidence and logical reasoning (Piatek-Jimenez et al. 2012, Vacher 2014)
- Mathematics and statistics applied in real-life, authentic situations that impact an individual's life as a constructive, concerned, and reflective citizen (Mayes et al. 2014)

The Problem

The Problem:

- Students in the United States consistently lag behind in science education outcomes (National Center for Education Statistics 2005)
- Students are graduating unable to apply quantitative knowledge to situations (Wilkins 2010)
- Little to no improvement between 1970-2012 (Mullis & Martin 2014)

The Implications:

- Students with low QR are more likely to drop out of school, experience unemployment, earn less (McMillan & Marks 2003, Marks et al. 2005, Rumberger & Lamb 2003)
- Left unprepared to address pressing social and scientific issues (Steen 1999)
  - These issues becoming more important as we increasingly rely on large, complicated datasets (NAP 2014)

Reform in Education

Fundamental shifts in science education

- Away from rote learning of facts
- Towards application of critical thinking and deep understanding

NGSS, ACT, AP Biology Framework emphasize:

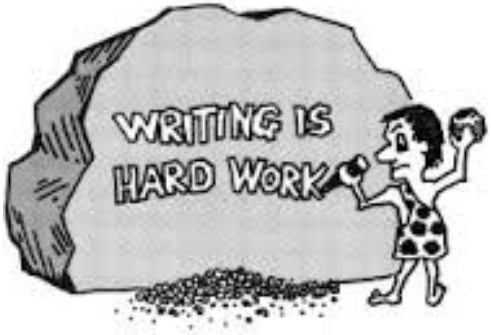
- Ability to **analyze and interpret** data
- The use of **mathematical** thinking
- Communication of **arguments** based on **evidence**

Constructing Explanations

Claim-Evidence-Reasoning (CER)

- Structure for constructing explanations
- Basis of scientific conclusions
- Consists of three parts:
  1. Restate the scientific questions with the answer that is suggested by examining the data.
  2. What evidence (data) supports your claim
  3. Reasoning links evidence to the claim using scientific principles

"We know it when we see it, but really how do we teach it?"

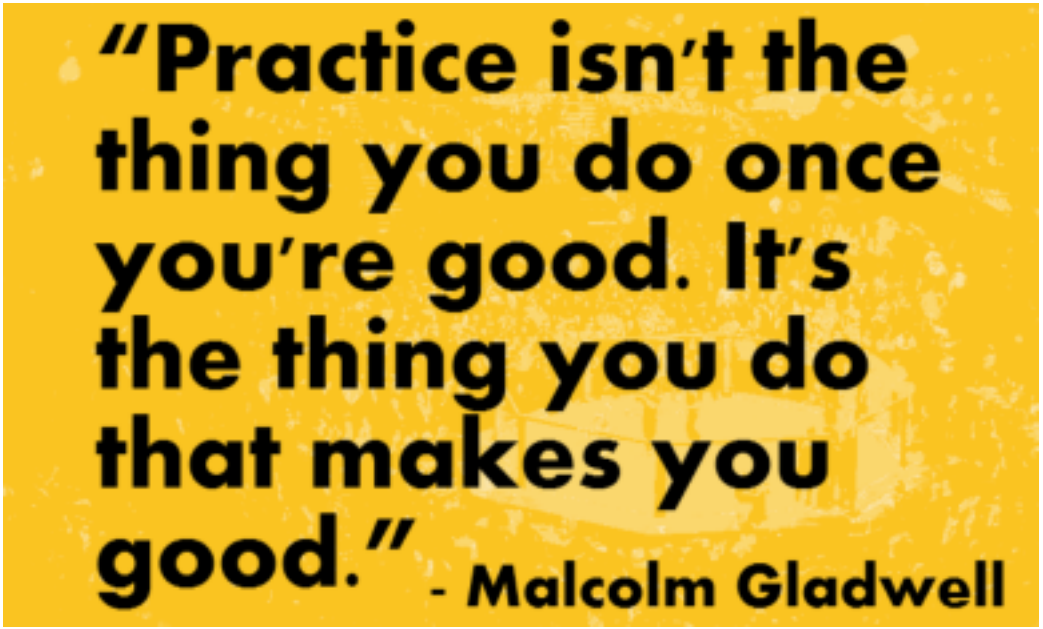


Why is CER Important?

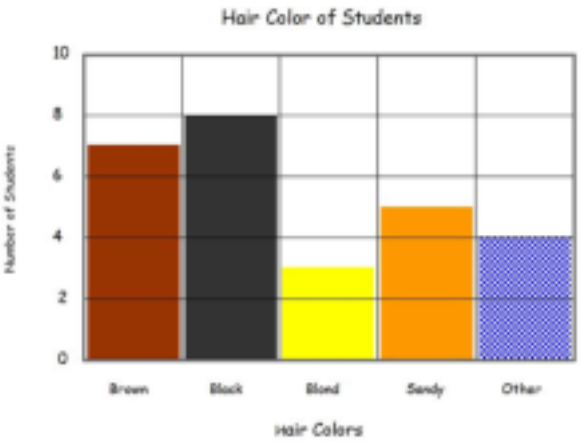
- Helps students evaluate how the evidence helps answer the scientific question presented in an experiment or reading material
- CER framework trains student thinking about looking at data and assists them in making their understanding clear in written responses
- Foundation for discourse that all students can engage in
- Prepares them to be discerning, thoughtful citizens in the future (we hope!)

Teaching CER needs to be intentional

- Explicit directions to students with modeling. They need to understand exactly what the learning objectives are and practice them!
- Begin with a simple sets of data and teach expectations of claim and evidence. That's the easy part.
- Reasoning is the most difficult of the practices – for teachers and students alike!
  1. Why does the evidence support the claim?
  2. Links the logic that supports the claim, describes the connection, supports real-world application


“Practice isn’t the thing you do once you’re good. It’s the thing you do that makes you good.” - Malcolm Gladwell

Identifying a Claim

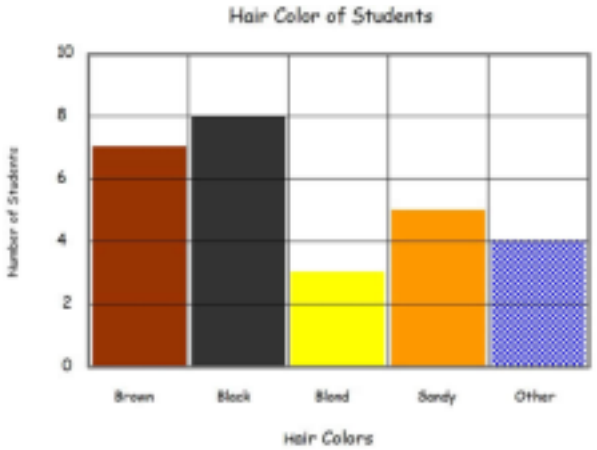


Restate the scientific question including the answer that is suggested by examining the data.

What might be the scientific question that fits this data?

Make a claim about the data.

Identifying the Evidence



What evidence supports your claim?

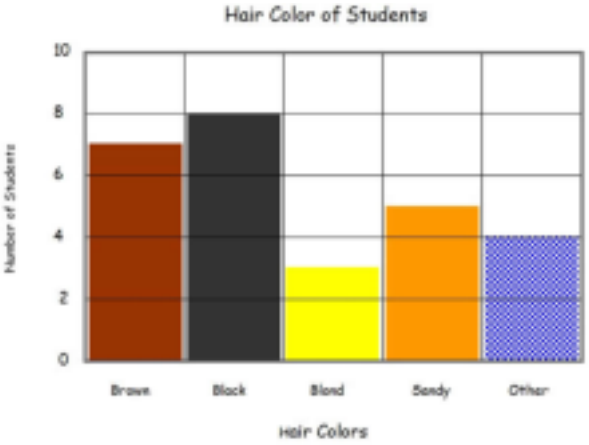
Applying Reasoning to CER

Claim - it allows us to look more closely at what the data is telling us.

Evidence - the data that has been gathered in response to an experiment, aims to provide an answer to the question.

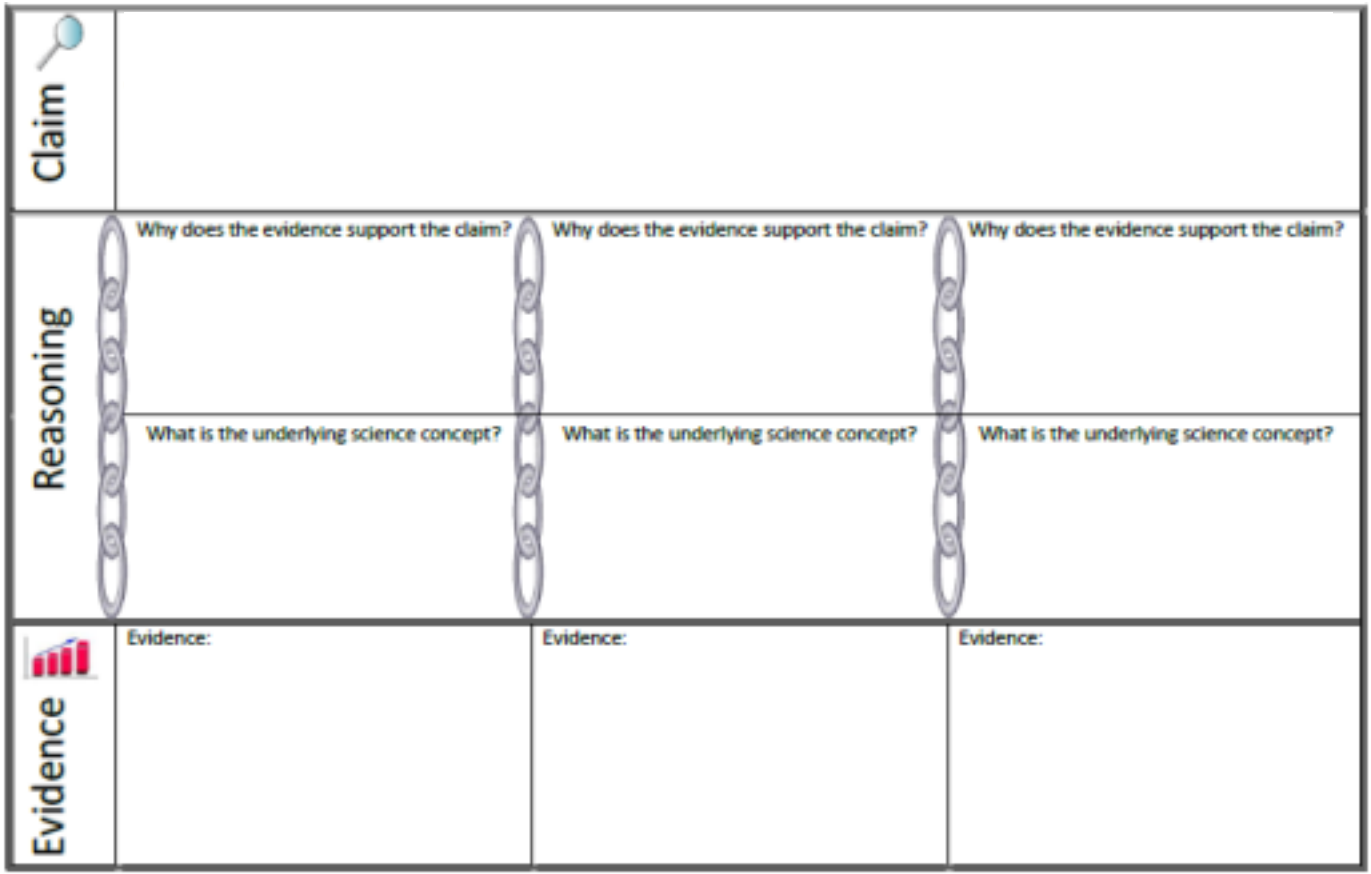
Reasoning - the connections between the evidence and the claim and the underlying scientific principles that relate to the claim.

Let's practice



What *scientific reasoning* links the data to the claim?

Scientific Question:



What are DATA Nuggets ?

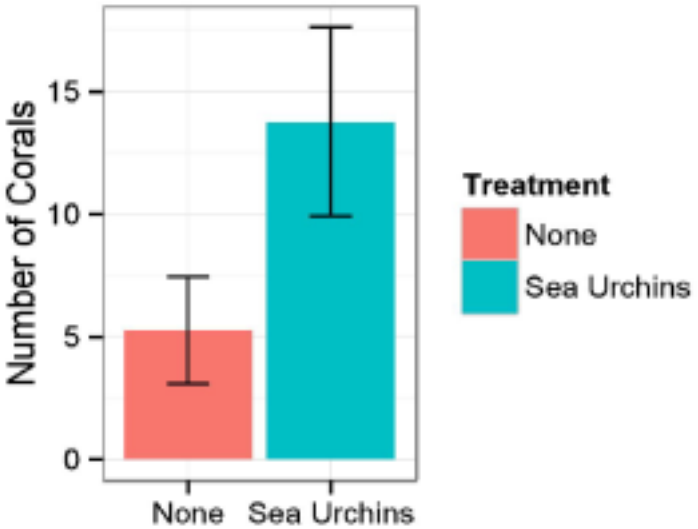
- Activities that bring real data into the classroom, along with all its messiness and complexity
- Based on authentic cutting edge research
- Guide students through the entire process of science, including data analysis & interpretation
- Take 30-60 minutes and follow familiar template

DATA Nugget

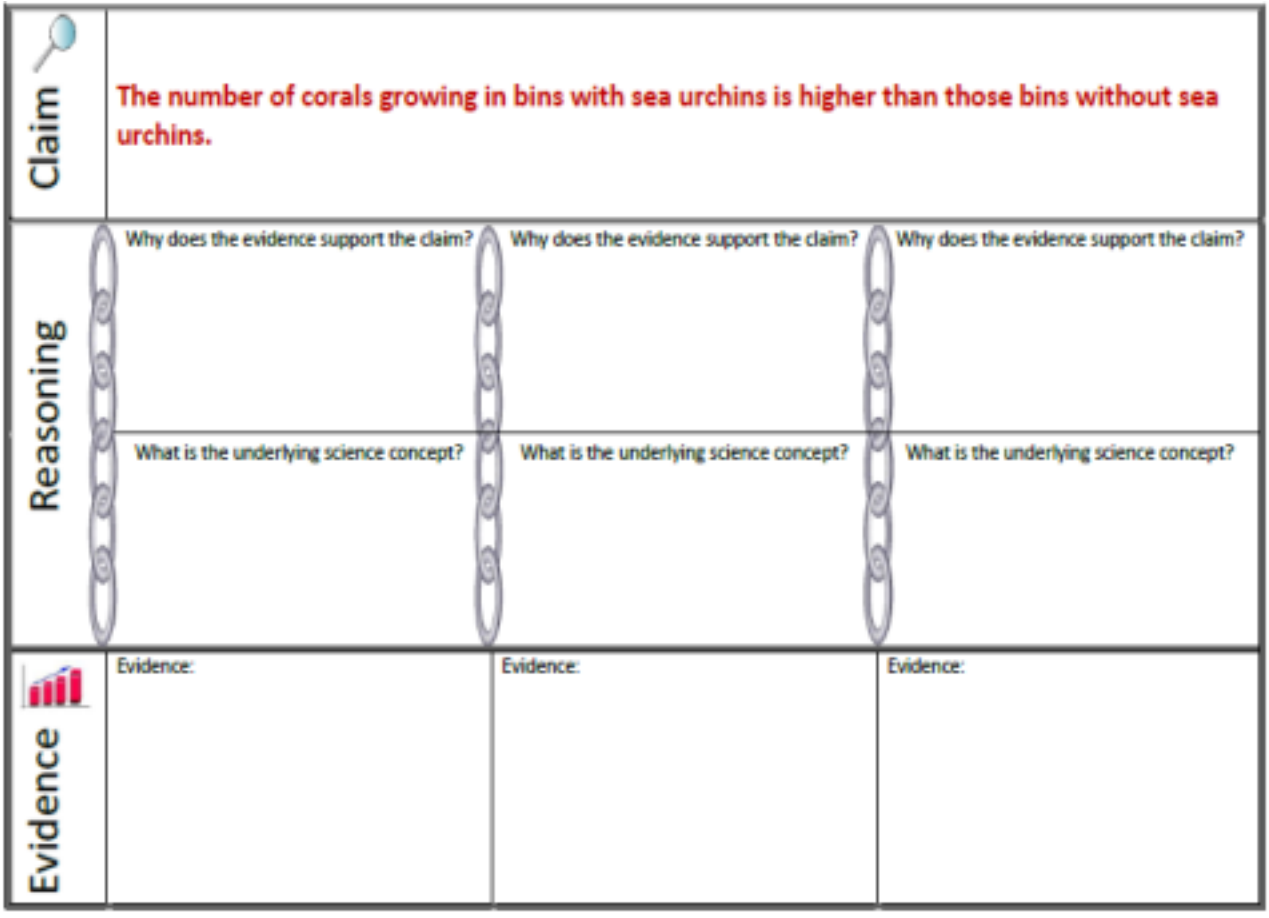
Won't you be my urchin?

Featured scientist: Sarah W. Davies from University of Texas at Austin

Scientific Question: How does the presence of urchins affect corals?



Step 1


Claim
The number of corals growing in bins with sea urchins is higher than those bins without sea urchins.
Reasoning
Why does the evidence support the claim?
What is the underlying science concept?
Why does the evidence support the claim?
What is the underlying science concept?
Why does the evidence support the claim?
What is the underlying science concept?
Evidence
Evidence:
Evidence:
Evidence:

Claim	**The number of corals growing in bins with sea urchins is higher than those bins without sea urchins.**		
Reasoning	Why does the evidence support the claim?	Why does the evidence support the claim?	Why does the evidence support the claim?
	What is the underlying science concept?	What is the underlying science concept?	What is the underlying science concept?
Evidence	Evidence: **The average number of corals on tiles with sea urchins was 13.75.**	Evidence: **The average number of corals on tiles without sea urchins was 5.25.**	Evidence:

Step 2

Step 3

Claim	The number of corals growing in bins with sea urchins is higher than those bins without sea urchins.		
Reasoning	Why does the evidence support the claim? The evidence supports the claim because in four trials, the average number of corals with sea urchins was higher.	Why does the evidence support the claim? The evidence supports the claim because in four trials, the average number of corals without sea urchins was lower.	Why does the evidence support the claim?
	What is the underlying science concept? The sea urchin eat the algae that can be competitive with corals, allowing corals to be more successful.	What is the underlying science concept? Without sea urchins, algae competes with the coral and limits the coral growth.	What is the underlying science concept?
Evidence	Evidence: The average number of corals on tiles with sea urchins was 13.75.	Evidence: The average number of corals on tiles without sea urchins was 5.25.	Evidence:

Criteria	Student 1	Score	Student 2	Score	Student 3	Score	Student 4	Score
Claim: Statement that answers the scientific question.	Just look at the graph.		The difference is more corals are growing on tiles with sea urchins than tiles without sea urchins.		The corals grew with and without sea urchins.		The tiles with sea urchins are affected more than the tiles without the sea urchins (less corals).	
Evidence: Scientific data that supports the claim.	Theres more corals with sea urchins.		My evidence is tiles with sea urchins have 2 ½ more corals growing on them than without sea urchins.		More corals grew with sea urchins 13 and 5 without sea urchins.		The corals with sea urchins had 13.75 and the tiles without sea urchins had 5.25.	
Reasoning: a. why evidence supports the claim and b. what the underlying science concept(s) does it link to.	Algae changes color.		The data supports it by having the tiles with sea urchins have more corals than the tiles without sea urchins. They are used to it.		Corals are helped by sea urchins.		It supports our claim because it shows sea urchins help corals grow.	

Evaluate Student Responses

Rank the set of student responses from best (1) to worst (10) for:

- Claims
- Evidence
- Reasoning

Scaffolding CER

- Before using Data Nuggets, students will need instruction in basic science principles
- Data Nuggets then provide practice in dealing with data and interpreting it
- Start off by heavily scaffolding students, and take away over time

You can't do Data Nuggets without teachers!

Talk Moves

Teachers can use to elicit better reasoning:

- “Do these data support the science concepts?”
- “Can you say/write more about that?”
- “Let me repeat back what I hear you saying….”
- “Why do you think that?”
- “Sally, can you repeat what Katie is saying in your own words?”
    - “Is that what you were saying?”
- “Does it always work that way?” or “Are there exceptions to this?”
- “Can you add some science details to that?”
- “How does the science relate to those results?”
- “What convinces you that this science concept explains the data?”

Talk Science Primer, TERC, 2012

Suggested Sentence Starters

1. My evidence supports my claim because _____, therefore _____.
2. My evidence supports the claim because _____ and it is important because _____.
3. The trend is showing us _____ that proves our claim is correct/incorrect and it is important to science because _____.

You might consider making bookmarks for your students. A C-E-R poster for your classroom might support better student writing.

Using the CER Tool

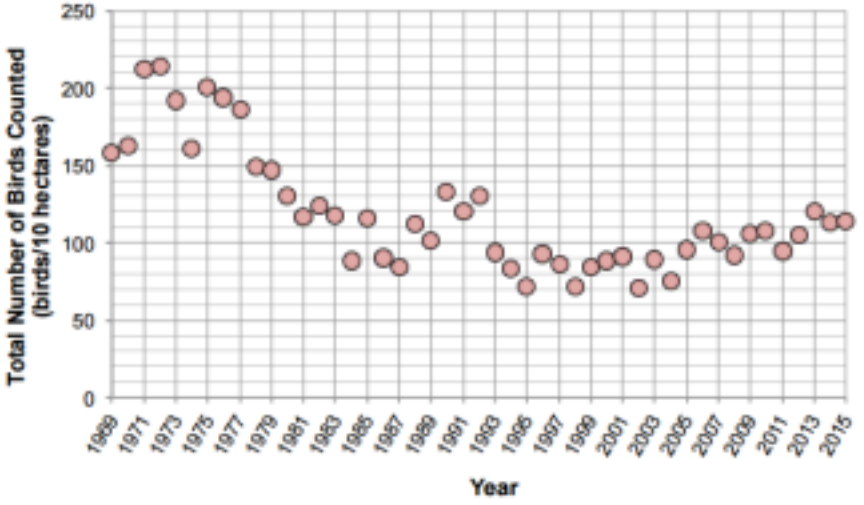
- As a pre-writing scaffold and turned in as a formative or summative assessment.
- A vehicle to discuss a table/graph orally with their classmates before completing the Data Nugget individually.
- As a structured exemplar before assigning CER as a written paragraph.

DATA Nugget

Bye Bye Birdie? Part I

Featured scientist: Richard Holmes from the Hubbard Brook Experimental Forest

Scientific Question: How has the total number of birds at the Hubbard Brook Experimental Forest changed over time?



Claim

The total number of birds at the Hubbard Brook Experimental Forest has gone down over time.

Reasoning

Why does the evidence support the claim?	Why does the evidence support the claim?	Why does the evidence support the claim?
The evidence shows a higher number of birds in 1969	The evidence shows a downward trend over time, from 1969 - 2015	
What is the underlying science concept?	**What is the underlying science concept?**	**What is the underlying science concept?**
Therefore, conditions in the forest were better for birds in 1969 than they were in 2015	Therefore, we can reason that there was some type of environmental change that caused the bird numbers to drop	

Evidence

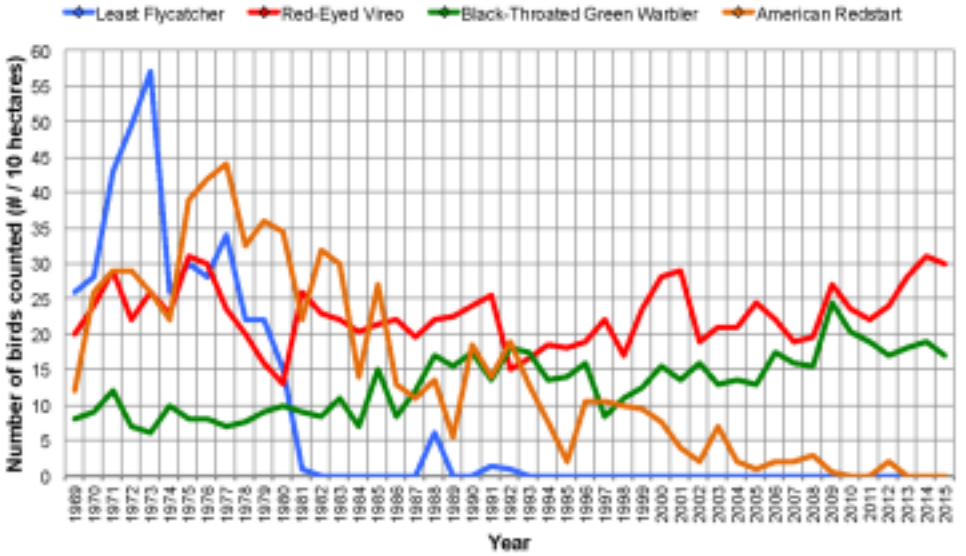
Evidence:	Evidence:	Evidence:
In 1969, there were a total number of 158 birds counted during the forest sampling	In 2015, there were 114 birds counted in the forest sampling	

DATA Nugget

Bye Bye Birdie? Part II

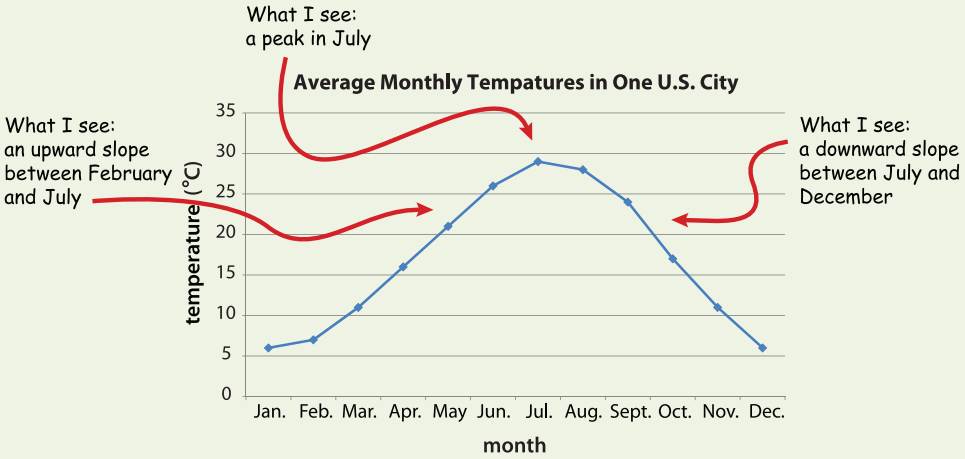
Featured scientist: Richard Holmes from the Hubbard Brook Experimental Forest

Scientific Question: What is the population trend of each bird species over the years 1969-2015?

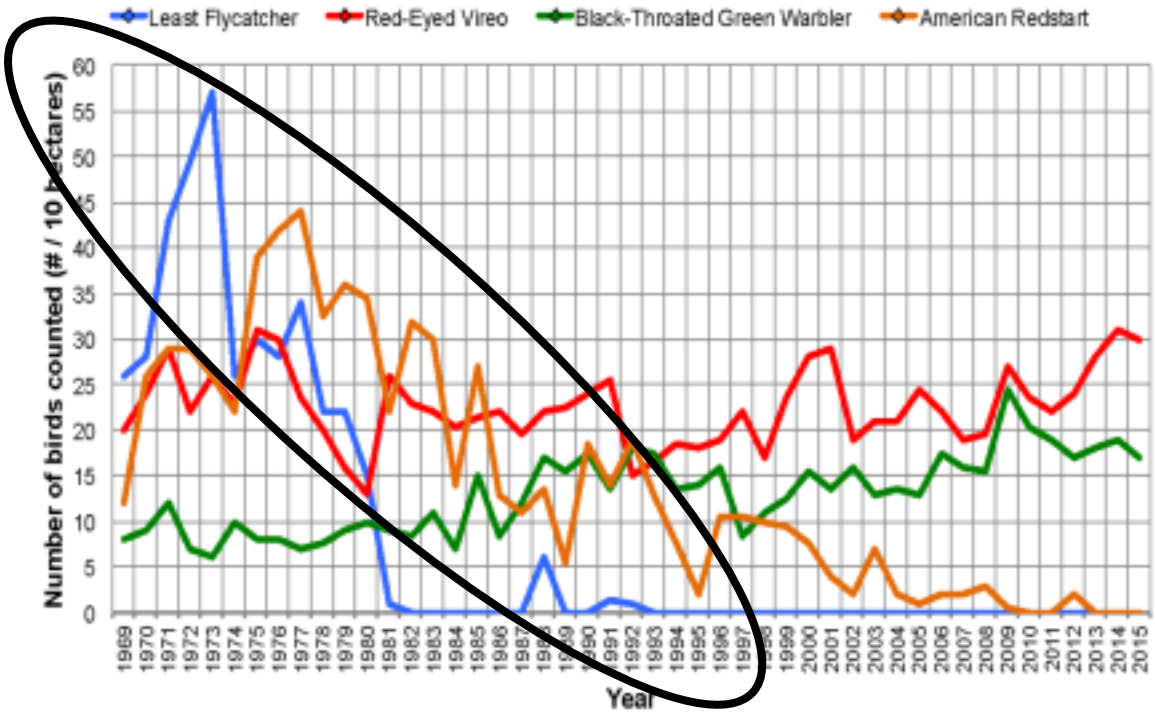


Scaffolding CER

Taking a step further back – I^2 tool

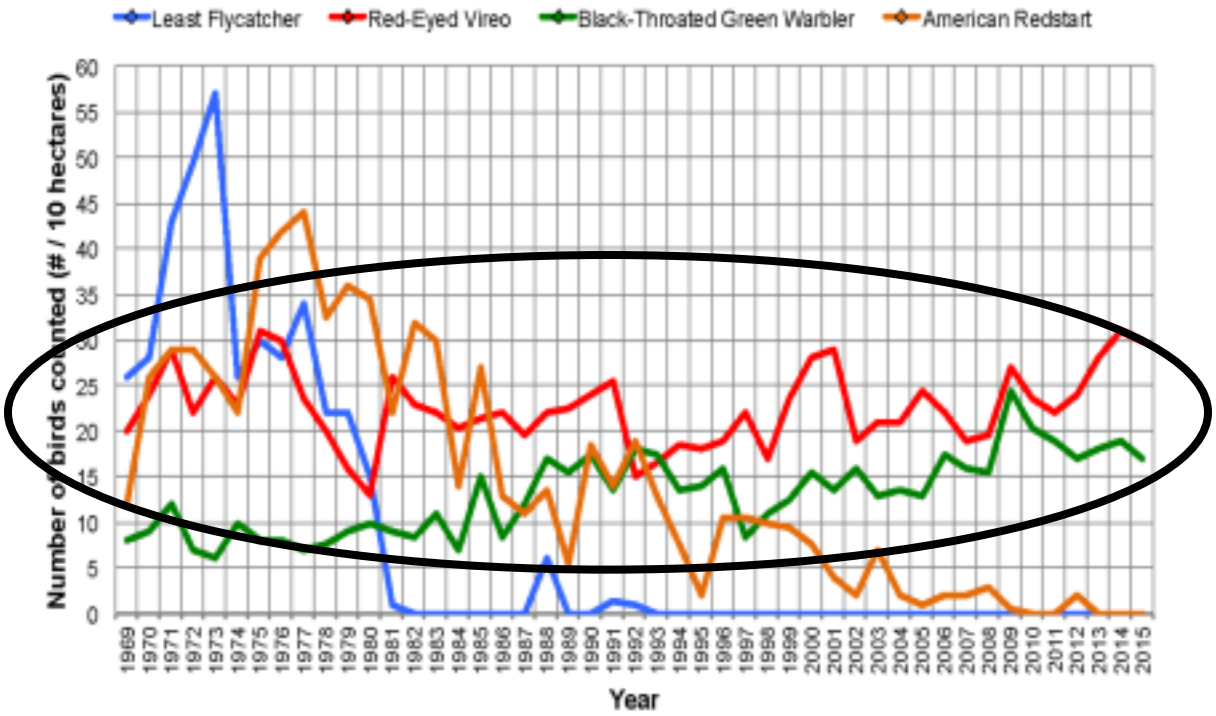
I^2 step	Example
Step 1: Identify ("What I see" comments) ■ Identify any changes, trends, or differences you see in the graph or figure. ■ Draw arrows and write a "What I see" comment for each arrow. ■ Be concise in your comments. These should be just what you can observe. ■ Do not try to explain the meaning at this point.	 For this example, there are arrows drawn that point to the two trends and the change. Notice that the arrows point to the general upward and downward trends, not to each data point. A "What I see" comment describes what each arrow points to on the graph.

Identify trends in the graph



Least Flycatchers went from the most abundant to the least abundant in less than 15 years

Identify trends in the graph



There are almost always more red-eyed vireos counted than black-throated green warblers

Claim

Bird population trends are different for each of the four species shown. Some have increased, some have decreased, and some have stayed the same.

Reasoning

Why does the evidence support the claim?	Why does the evidence support the claim?	Why does the evidence support the claim?	Why does the evidence support the claim?
The evidence from sampling shows that the Least Flycatcher population has dropped	The evidence from sampling shows that the Red-eyed Vireo population has remained constant	The evidence from sampling shows that the Black-Throated Warbler population has increased	The evidence from sampling shows that the American Redstart population has dropped.
What is the underlying science concept?	**What is the underlying science concept?**	**What is the underlying science concept?**	**What is the underlying science concept?**
Therefore, since the flycatcher prefers semi-open spaces in the forest, as forest succession progressed and less open space was available, their populations decreased as they migrated elsewhere.	Need some explanation – the vireo should not be successful in early disturbed ecosystem	Black-Throated Green Warbler is versatile in its habitat, able to be successful under many circumstances, although it is more successful as forests are less disturbed.	American redstart prefers conditions similar to the Least Flycatcher, preferring mid-successional forests with open spaces, avoiding forests with abundant cover.

Evidence

Evidence:	Evidence	Evidence	Evidence
Least Flycatcher population went from 26 in 1969 to 0 by 1993 and have been absent from the forest since then.	Red-eyed Vireo population shows minimal change. There were 20 birds in 1969 and in 2015 there were 30	Black-Throated Green Warbler population has increased from 8 birds in 1969 to 17 birds in 2015	American Redstart population was 12 in 1969 and diminished to 2 or less after 2008

Assessing Student Understanding

Classroom Assessments

- Data Nuggets have also been used as formative and summative assessments
- Rubric developed to facilitate the use of DNs as assessments
  - Currently being revised after working with expert teachers (please provide any feedback!)

Data Nuggets Rubric

Criteria	0	1	2	3	#
Hypothesis	No attempt made to underline text.	Incorrect sentence underlined AND none of the hypothesis.	Part/all of hypothesis AND other text.	Only and all of hypothesis (not prediction).	
Variables	No attempt to list variables.	Neither variable listed is correct.	Only one variable is correct OR only one of the multiple correct variables listed OR extra, unnecessary variables are listed.	Both variables correctly and clearly identified AND multiple variables listed, if appropriate.	
Graph	No attempt to graph OR graph is missing five graph components from list under score 3.	Chose incorrect type of graph OR chose correct type AND missing three or four graph components from list under score 3.	Chose correct type of graph AND missing two components from list under score 3.	Chose correct type of graph AND missing no more than one component: □ Labeled one or both axes correctly. □ Include units on one or both axes, if applicable. □ Data points are graphed correctly. □ Can differentiate variables or categories on graph (i.e. key) □ Trendline or error bars are included, where applicable, and are drawn correctly.	
Data Interpretation					
Claim	No claim written OR claim is missing more than three of the criteria listed under score 3.	Claim is missing three of the criteria listed under score 3.	Claim is missing two of the criteria listed under score 3.	Claim is missing no more than one of the following criteria: □ Correct (based on graph) □ Clearly stated □ Answers the question □ Complete and includes all relevant variables □ Minimal extra information (such as evidence)	
Evidence	No evidence OR evidence is missing more than three of the criteria under score 3.	Evidence is missing three of the criteria listed under score 3.	Evidence is missing two of the criteria listed under score 3.	Evidence is missing no more than one of the following: □ Correct (based on claim) □ Clearly stated using complete sentences □ Provides all necessary evidence related to claim (comparison, trend, etc.) □ Quantitative, not just qualitative □ References table or graph, preferably a specific part	

Assessing Student Understanding

This rubric can help you answer:

- What do your students understand at the beginning of the school year? Where are their skill levels?
- What areas are your students getting stuck?
- What aspects of the scientific process do you need to address misconceptions?
- Did your students understand the scientific content?
- Have your students improved over the course?
- Are your students ready to analyze and interpret data on standardized tests?

References

Allen, Jared and Rogers, Meredith Park, Putting Ideas on Paper, Science and Children, November 2015, pg. 32-37, NSTA Press, Retrieved July 8, 2016

Grymonpre`, Kris, Cohn, Allision and Solomon, Stacey, Getting Past "Just Because": Teaching Writing in Science Class, Science Scope, January 2012, pg. 24-31, NSTA Press, Retrieved July 8, 2016

Keeley, Page, Constructing CI-Ev-R Explanations to Formative Assessment Probes, Science and Children, November 2015, pg. 26-28,NSTA Press Retrieved July 8, 2016

Krajcik, Joe, Preparing for NGSS: Engaging in Argument from Evidence, http://learningcenter.nsta.org/products/symposia_seminars/ngss/files/PreparingforNGSS--EngaginginArgumentfromEvidence_12-4-2012.pdf , Retrieved July 8, 2016

Krajcik, Joseph S. and McNeill, Katherine L., Assessing Middle School Students' Content Knowledge and Scientific Reasoning Through Written Expressions, http://www-personal.umich.edu/~krajcik/McNeill&Krajcik_NSTA.pdf, Retrieved July 8, 2016

Krajcik, Joseph S. and McNeill, Katherine L., Creating Explanation Assessment Tasks, http://umaine.edu/center/files/2011/06/Krajcik-Handout-with-examples.pdf, Retrieved July 8, 2016

McNeill, Katherine and Krajcik, Joseph, Inquiry and Scientific Explanations: Helping Students Use Evidence and Reasoning, http://bscs.org/sites/default/files/_media/about/downloads/ap_bio_scientific_explanation_tool.pdf, Retrieved July 8, 2016

McNeill and Martin, Dean M., Claims, Evidence and Reasoning: Demystifying Data During a Unit on Simple Machines, Science and Children, April/May 2011, pg. 52-56, Retrieved July 8, 2016

References, continued

Sutherland, LeeAnn, If You Only Concentrate on One New Strategy, Make it Claim, Evidence and Reasoning (CER), http://www.activatelearning.com/claim-evidence-reasoning/, Retrieved July 8, 2016

Wheeler-Toppen, Jodi, How Do You Know That? Helpinng Students Write About Claims and Evidence, NSTA Web Seminar, https://learningcenter.nsta.org/products/symposia_seminars/NSTA/files/HowDoYouKnowThat--HelpingStudentsWriteAboutClaimsandEvidence_12-12-2012.pdf, Retrieved July 8, 2016

Scientific Explanation Tool: Guide for Teachers, http://bscs.org/sites/default/files/_media/about/downloads/ap_bio_scientific_explanation_tool.pdf , Retrieved July 8, 2016

Next Generation Science Assessment Project, Unpacking Scientific Explanation, https://www.nsta.org/conferences/docs/2015SummerInstituteSecondary/ScientificExplanationExampleRubricFinal.pdf, Retrieved July 8, 2016

Reasoning when Writing Scientific Arguments, http://scienceaarguments.weebly.com/uploads/2/6/4/3/26438648/reasoning_w_construct_map.pdf, Retrieved July 8, 2016

How to Write a Scientific Explanation, http://bscs.org/sites/default/files/_media/about/downloads/scientific_explanation_tool.pdf, Retrieved July 8, 2016

Claim, Evidence, Reasoning: Tools to Introduce CER in PD and Instruction, https://teachscience4all.org/2012/11/21/claim-evidence-reasoning-tools-to-introduce-cer-in-pd-and-instruction/, Retrieved July 8, 2016

Claims, Evidence and Reasoning Sentence Starters, http://ambitiousscienceteaching.org/wp-content/uploads/2014/10/D3-sentence-starters-Claim-Evidence-sound-unit-3rd.pdf. Retrieved July 20, 2016