DATA Nuggets

Ways to use data analysis and classroom discourse with authentic research to unearth students' quantitative and inquiry skills

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and Melissa Kjelvik

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**

What are Data Nuggets?

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

Learning Objectives

Through the repeated use of Data Nuggets in the classroom, students will:

1. Understand that science is an active process and how we learn about the natural world.
2. Identify and differentiate between scientific questions, hypotheses, and predictions.
3. Build their quantitative skills by working with data, graphing, and interpreting quantitative information.
4. See science as an approachable and attainable career.

Predicted student gains when using Data Nuggets

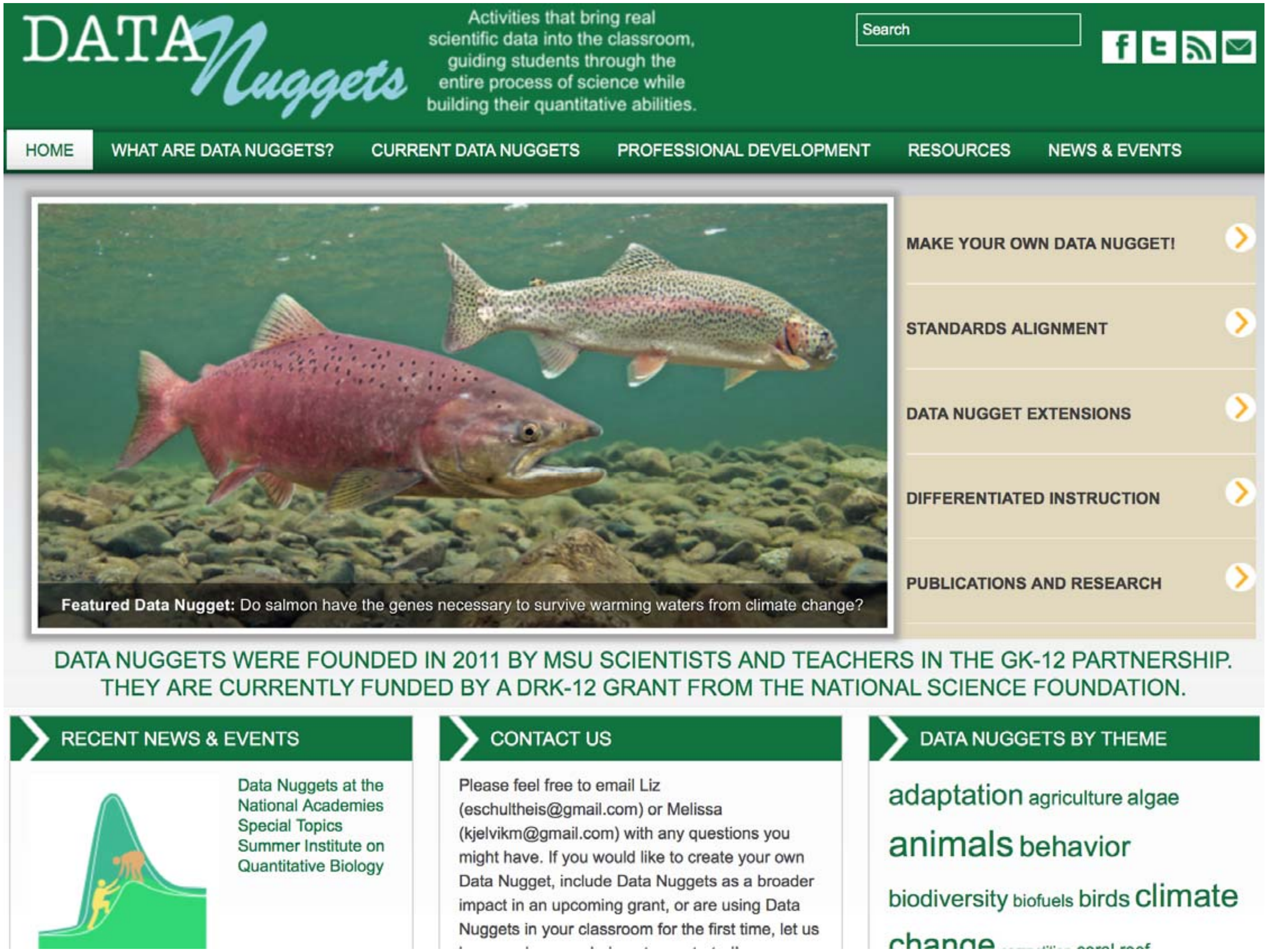
- Teacher survey results:
  - “Students were more interested and engaged in science because they knew they were working with real data.”
  - “Students were better able to think critically about data and communicate their findings to their peers and through writing.”
  - “Because of their new comfort with data, students were more excited to conduct their own inquiry projects and graph.”
  - Ability to analyze and interpret data, identify data ranges and trends, and appropriately question the reliability of data and outliers, all improved.

Future Data Nugget Opportunities

Efficacy Study

- We will be looking for teachers to participate in a one-year research study ($$)
- Integrating Data Nuggets into your classroom

Data Nuggets in the Classroom


DATA Nuggets
Activities that bring real scientific data into the classroom, guiding students through the entire process of science while building their quantitative abilities.
Search
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Featured Data Nugget: Do salmon have the genes necessary to survive warming waters from climate change?
MAKE YOUR OWN DATA NUGGET!
STANDARDS ALIGNMENT
DATA NUGGET EXTENSIONS
DIFFERENTIATED INSTRUCTION
PUBLICATIONS AND RESEARCH
DATA NUGGETS WERE FOUNDED IN 2011 BY MSU SCIENTISTS AND TEACHERS IN THE GK-12 PARTNERSHIP.
THEY ARE CURRENTLY FUNDED BY A DRK-12 GRANT FROM THE NATIONAL SCIENCE FOUNDATION.
RECENT NEWS & EVENTS
Data Nuggets at the National Academies Special Topics Summer Institute on Quantitative Biology
CONTACT US
Please feel free to email Liz (eschultheis@gmail.com) or Melissa (kjelvikm@gmail.com) with any questions you might have. If you would like to create your own Data Nugget, include Data Nuggets as a broader impact in an upcoming grant, or are using Data Nuggets in your classroom for the first time, let us
DATA NUGGETS BY THEME
adaptation agriculture algae
animals behavior
biodiversity biofuels birds climate

DATA Nuggets

Activities that bring real scientific data into the classroom, guiding students through the entire process of science while building their quantitative abilities.

Search

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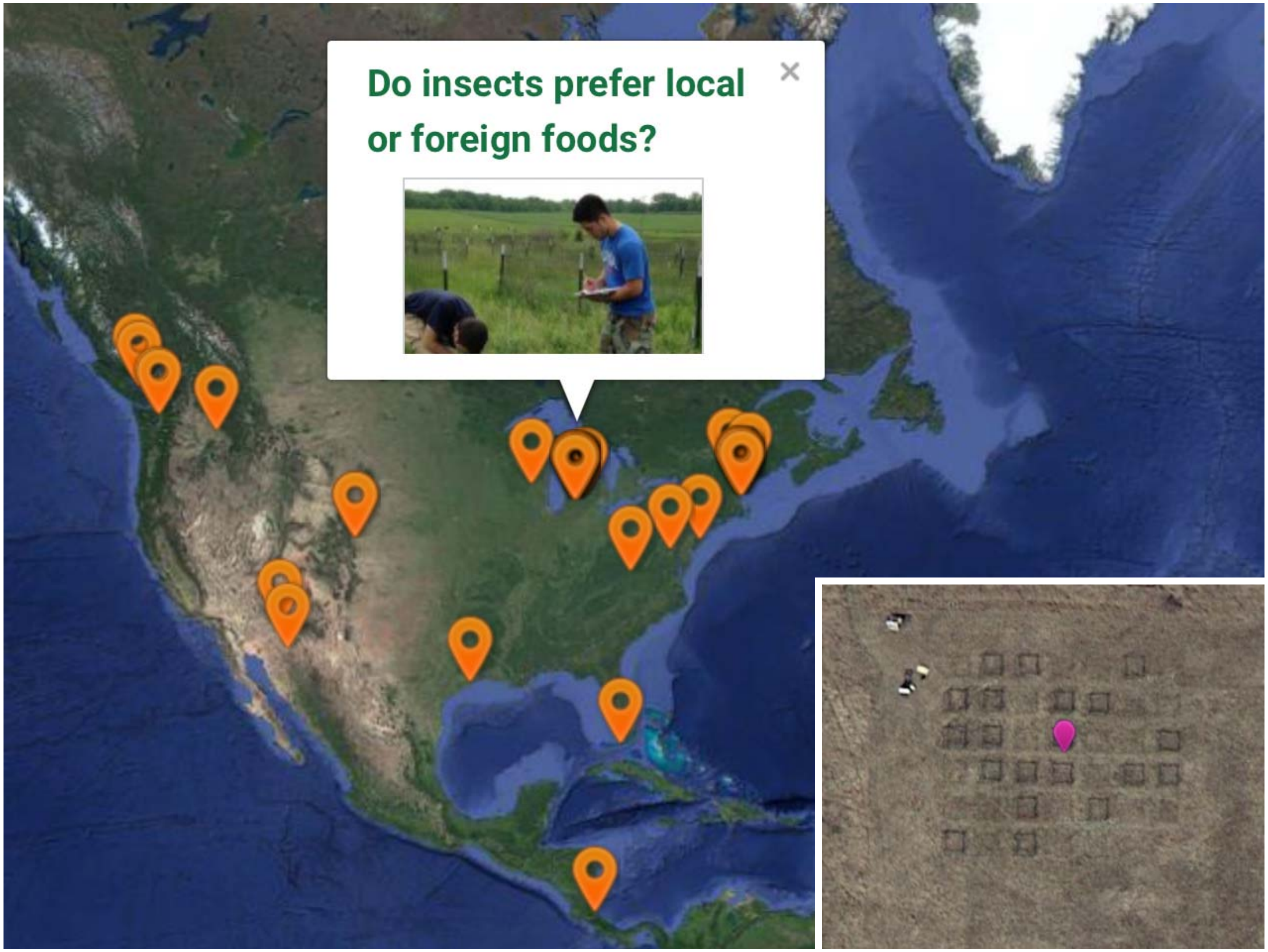
Search Current Data Nuggets

Below, you will find a **table** of all the current Data Nuggets available. Click on the Title to open a page displaying the Data Nugget and associated activities. The table can be **sorted** using the arrows located next to each column header. It can also be **searched** using the search command at the top of the table.

	Title	Keywords	Summary	Content Level	Study Location
	A tail of two scorpions	animal behavior, animals, predation	Species rely on a variety of methods to defend against predators, including camouflage, speedy escape, or retreating to the safety of a shelter. Other animals, such as scorpions, have painful venomous stings. Scientists wanted to know whether the pain of a scorpion sting was enough to deter predators, like the grasshopper mouse.	2	Santa Rita Mountains, Arizona & Michigan State University
	CSI: Crime Solving Insects	animals, insects, parasitism	You might think maggots (blow fly larvae) are gross, but without their help in decomposition we would all trip over dead bodies every time we went outside! Forensic entomologists also use these amazing insects to help solve crimes. Blow flies oviposit on dead bodies, and the age of the maggots that hatch helps scientists determine how long ago a body died. Scientists noticed parasitic wasps were also present at some bodies. Might these wasps delay blow fly oviposition and interfere with scientists' estimates of time of death?	3	Pierce Cedar Creek Institute, Michigan & Valparaiso University, Indiana
	Shooting the poop	adaptation, animal behavior, animals, insects, predation	Caterpillars are a great source of food for many species. The silver-spotted skipper caterpillar has a variety of defense strategies against predators, including building leaf shelters for protection. This caterpillar was also discovered to "shoot its poop", sometimes launching it over 1.5m! Might this very strange behavior serve as	2	Georgetown University, Washington DC


Do insects prefer local or foreign foods?

DATA Nuggets

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MEET THE SCIENTISTS!

Want to know more about the scientists behind each Data Nugget? Click on their name for a link to their professional websites, or on their Data Nugget to learn more about their research!

	Lauren Kinsman-Costello	Kent State University & Michigan State University	I am an ecosystem ecologist interested in the effects of hydrology on aquatic nutrient biogeochemistry and ecosystem function. My research aims to inform larger questions about the resilience of ecosystems faced with environmental change and the ability of humans to manage, restore, and create ecosystems. A recurring theme in my research is the role that sediments play in freshwater ecosystem function (mud matters!).	Marvelous mud
	Melissa Kjelvik	Michigan State University & Data Nuggets	I am a postdoctoral researcher and co-founder of Data Nuggets. I completed my PhD in Zoology and EEBB at the Kellogg Biological Station as a member of Gary Mittelbach's Lab. For my research I work with juvenile bluegill sunfish. I am interested in how fitness tradeoffs may lead to the maintenance of individual-level biodiversity, particularly in the behaviors of fish.	Dangerously bold
	Alycia Lackey	Michigan State University & Murray State University	My research lies at the intersection of evolution, ecology, and behavior. I am interested to examine how populations evolve in response to the environment, especially in cases of environmental change. I study what generates, maintains, and erodes diversity within and between populations. In my Ph.D. research, I explored the evolution of reproductive isolation between limnetic and benthic threespine stickleback fish species pairs. I examined both how divergent sexual and natural selection maintained distinct species and how environmental change facilitated hybridization between one species pair. I am enthusiastic about teaching, mentoring, and outreach.	Which guy should she choose? & Fish fights

Content Levels

Level 1	• Elementary and above
Level 2	• Middle School and above
Level 3	• High School and above
Level 4	• Advanced High School students • College undergraduates

- These correspond with Flesch-Kincaid readability statistics
- Aligned with NGSS Standards

Graphing Levels

Type A graph provided	• Data: displayed on graph • Axis labels and scale provided
Type B	• Data: student graphs data • Axis labels and scale provided
Type C student creates graph	• Data: student graphs data • Axis labels and scale not provided

- Each Data Nugget is provided in each type on our website
- Scientist provides us with Type A and excel file, we make the rest

Using the Teacher Guide

Teacher Notes: Provide additional background information for teachers, as well as suggestions for discussion topics.

Checks for Understanding: Provide stopping points for teachers to assess student understanding.

Meta Moments: Provide stopping points for teachers to have a conversation with their students about the process of science itself. Stepping back from the research, students can discuss the decisions they are making as they work though the Data Nugget.

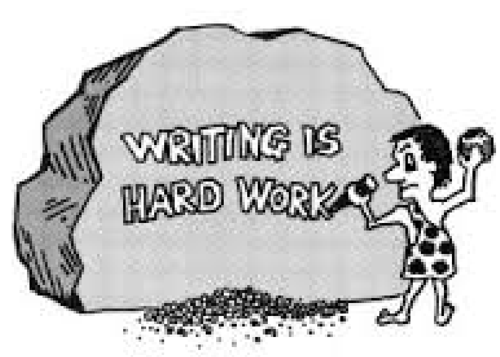
Using the Teacher Guide

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?

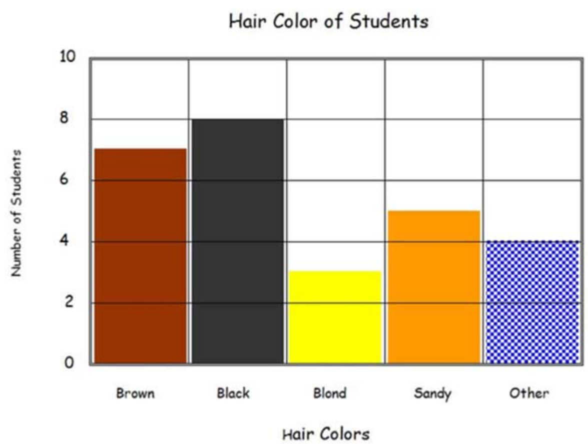
- Helps students evaluate how the evidence helps answer the scientific question presented in an experiment or reading material
- CER framework trains student thinking about looking at data and assists them in making their understanding clear in written responses
- Foundation for discourse that all students 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

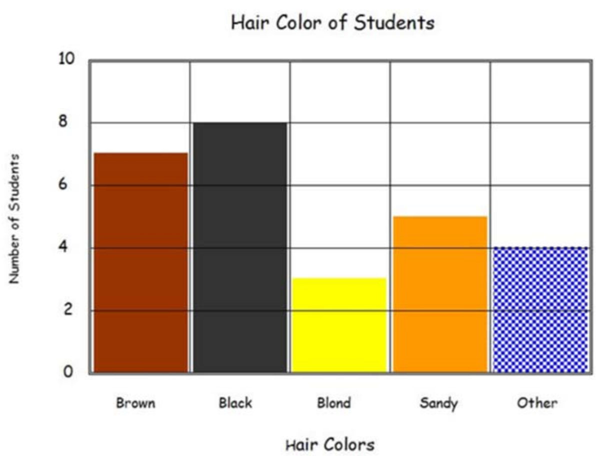


Restate the scientific question including the answer that is suggested by examining the data.

What might be the scientific question that fits this data?

Make a claim about the data.

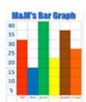
Identifying the Evidence



What evidence supports your claim?

Applying Reasoning to CER

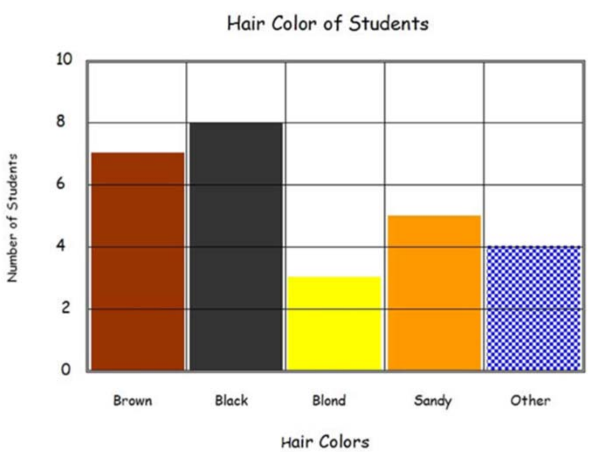
Claim - it allows us to look more closely at what the data is telling us.



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?

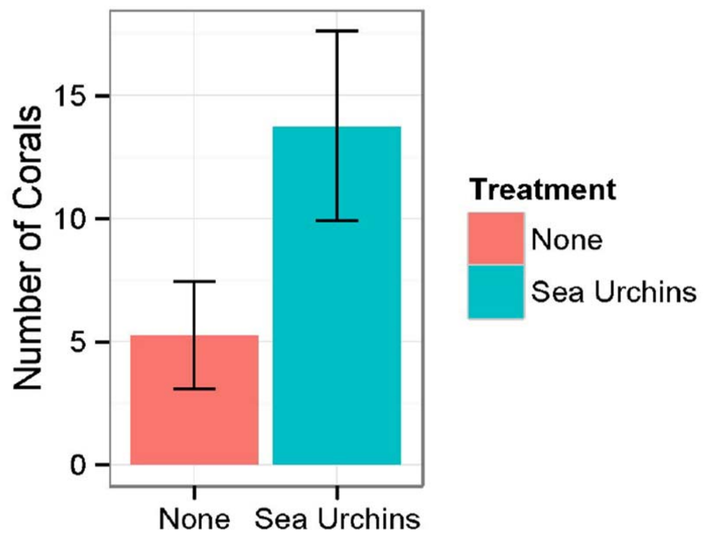
Scientific Question:

Claim			
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:	Evidence:	Evidence:

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?	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:	Evidence:	Evidence:

Slide 33

3 I really like this table, especially the way it is visually demonstrated that the "reasoning" is a link between the "Claim" and the "Evidence." However, I had a hard time when I first started using it since most tables are filled out in order. In this one, the top row is filled out first, then the bottom row. Then students go back and fill in the middle. I'm sure I can get used to it, but I wonder if students will have a hard time with that at all? It's not a huge problem, but perhaps something to consider.

-Kristy Campbell

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.

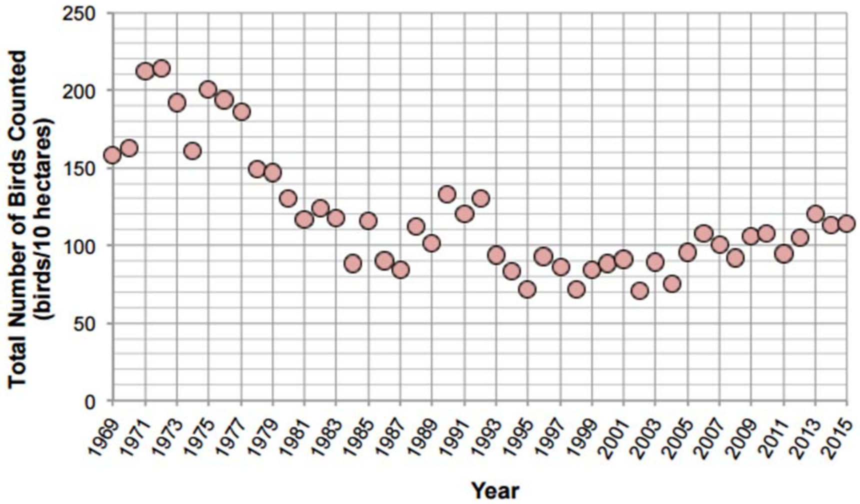
Using the CER Tool

- 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.

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?** The evidence shows a higher number of birds in 1969	**Why does the evidence support the claim?** The evidence shows a downward trend over time, from 1969 - 2015	**Why does the evidence support the claim?**
	What is the underlying science concept? Therefore, conditions in the forest were better for birds in 1969 than they were in 2015	**What is the underlying science concept?** Therefore, we can reason that there was some type of environmental change that caused the bird numbers to drop	**What is the underlying science concept?**
Evidence	**Evidence:** In 1969, there were a total number of 158 birds counted during the forest sampling	**Evidence:** In 2015, there were 114 birds counted in the forest sampling	**Evidence:**

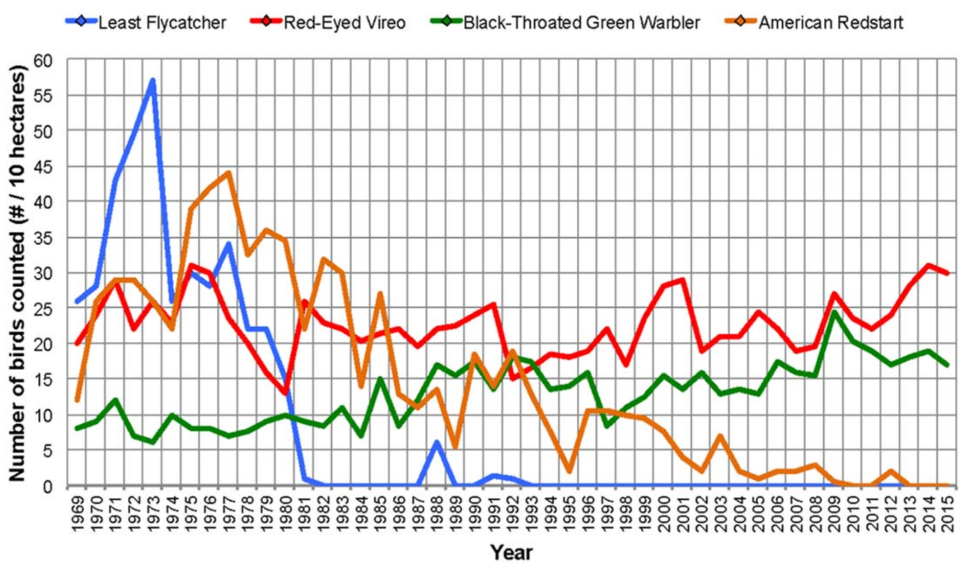
Slide 43

1 I really like this table, especially the way it is visually demonstrated that the "reasoning" is a link between the "Claim" and the "Evidence." However, I had a hard time when I first started using it since most tables are filled out in order. In this one, the top row is filled out first, then the bottom row. Then students go back and fill in the middle. I'm sure I can get used to it, but I wonder if students will have a hard time with that at all? It's not a huge problem, but perhaps something to consider.
-Kristy Campbell

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

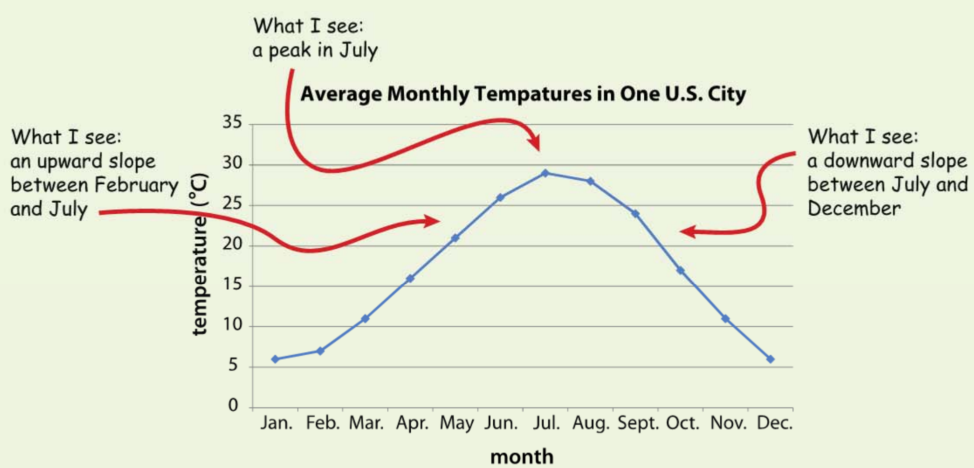
Taking a step further back – I^2 tool

<table>
<tr><th>I² step</th><th>Example</th></tr>
<tr><td>

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.

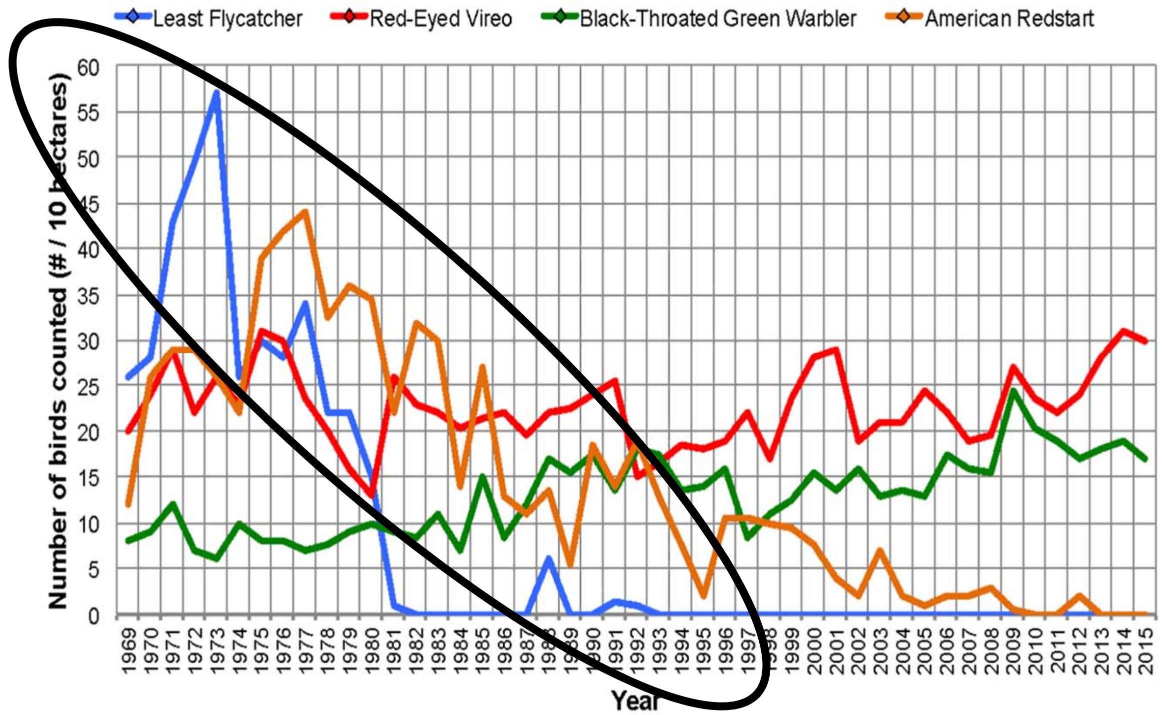
</td><td>



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.

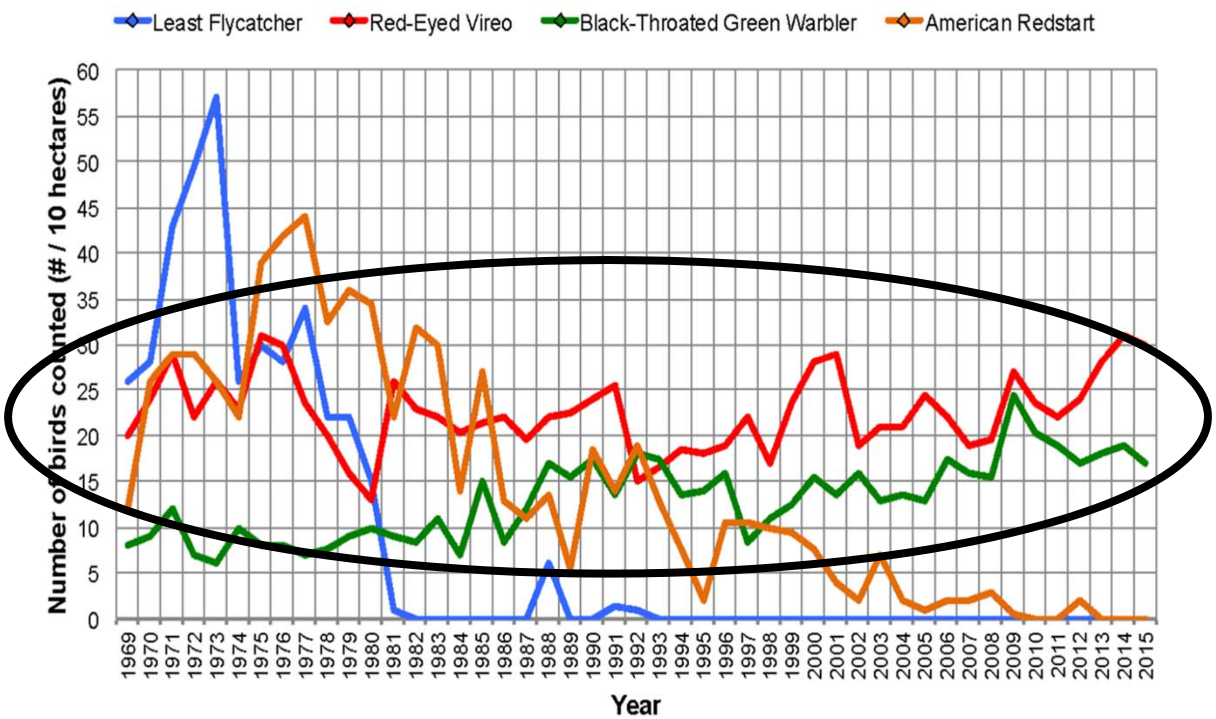
</td></tr>
</table>

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? The evidence from sampling shows that the Least Flycatcher population has dropped	Why does the evidence support the claim? The evidence from sampling shows that the Red-eyed Vireo population has remained constant	Why does the evidence support the claim? The evidence from sampling shows that the Black-Throated Warbler population has increased	Why does the evidence support the claim? The evidence from sampling shows that the American Redstart population has dropped.
	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.	What is the underlying science concept? Need some explanation – the vireo should not be successful in early disturbed ecosystem	What is the underlying science concept? 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.	What is the underlying science concept? American redstart prefers conditions similar to the Least Flycatcher, preferring mid-successional forests with open spaces, avoiding forests with abundant cover.
Evidence	Evidence: Least Flycatcher population went from 26 in 1969 to 0 by 1993 and have been absent from the forest since then.	Evidence Red-eyed Vireo population shows minimal change. There were 20 birds in 1969 and in 2015 there were 30	Evidence Black-Throated Green Warbler population has increased from 8 birds in 1969 to 17 birds in 2015	Evidence American Redstart population was 12 in 1969 and diminished to 2 or less after 2008

Thank you!

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 summer 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?

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