Engaging in Science Practices:
Explanation and Argumentation

Kate McNeill & Maria Gonzalez-Howard
Boston College

Our Challenge for Today

- "When asked how to aid educators in their understanding of the NGSS, I propose starting with the practices. For instance, having teachers engage in collegial debates about the difference between argument and explanation, one of the most difficult distinctions, is invaluable in understanding the NGSS." (Pruitt, 2014, p. 148)

Agenda

- Overview and Introductions
- Activity 1: Examine 6th grade transcript
- Activity 2: Analyze NGSS Appendix F
- Presentation: CER Framework vs NGSS definitions
- Discussion: Revisit 6th grade transcript

BREAK

- Presentation: Examples of explanations & arguments
- Activity 3: Examine student writing
- Presentation: Strategies to design lessons
- Activity 4: Redesign a science lesson
- Conclusions and Discussion

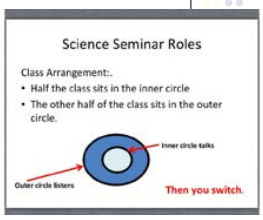
PowerPoint at: http://www.katherinelmcneill.com

Introductions

- Introduce yourself to the group
  - Name
  - School or Institution
  - Position (e.g. grade level and topics)

Activity 1: Examine Transcript

- 6th grade classroom
- Earth Science Unit focused on *Currents and Earth's Climate*
- Science Seminar



- Class Question - *Why is the Atacama Desert the driest place on Earth, with some parts that haven't had any precipitation in hundreds of years?*

Activity 1: Examine Transcript

- *Which of the 8 NGSS scientific practices do you see in this discussion? Where are occurring?*
- Eight NGSS Scientific Practices
  1. Asking questions and defining problems
  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 and designing solutions
  7. Engaging in argument from evidence
  8. Obtaining, evaluating, and communicating information

Activity 2: Analyze Appendix F

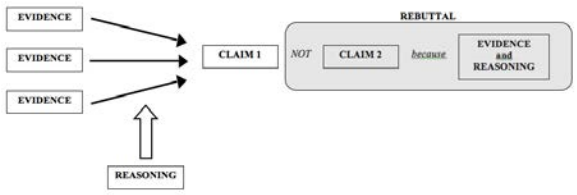
- Appendix F: Science and Engineering Practices in NGSS
- With your table, examine the explanation and argument tables focusing on grades 6-8.
  - What do you see as the similarities between the 2 practices?
  - What do you see as the differences between the 2 practices?
  - Use a large piece of chart paper to illustrate your findings (i.e. Venn diagram, table, etc.)

CER Framework

(McNeill & Krajcik, 2012)

- **Claim**
  - a conclusion about a problem
- **Evidence**
  - scientific data that is *appropriate* and *sufficient* to support the claim
- **Reasoning**
  - a justification that shows why the data counts as evidence to support the claim <u>and</u> includes appropriate scientific principles
- **Rebuttal**
  - describes alternative explanations and provides counter evidence and reasoning for why the alternative is not appropriate.

CER Framework *(McNeill & Krajcik, 2012)*



Physics Example

Does mass affect how quickly an object falls?

No, mass does not affect how quickly an object falls. (Claim) In our experiment, the blocks had different masses – 20 g., 30 g., 44 g., 123 g and 142 g. But the average time for all five blocks was about the same - between 1.5 and 1.8 seconds. (Evidence) Since the blocks had different masses but took about the same time, I know that mass does not affect how quickly something falls. (Reasoning)

Biology Example

What will happen to the shark population if the phytoplankton populations die out?

The shark population will die out.(Claim) The shark eats other fish such as the ocean fish and the lantern fish. The ocean fish and the lantern fish eat other organisms such as shrimp and copepods. The shrimp and copepods eat the phytoplankton. (Evidence) Phytoplankton are producers and they make their own food from the sun. All of the other organisms in the food web depend on the phytoplankton, even if they do not directly eat them. If the phytoplankton die, primary consumers (shrimp and copepods) will die because they will have no food which will cause the secondary consumers (ocean fish and lantern fish) to die, which will cause the shark to die. (Reasoning)

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Environmental Science Example

Mr. Garcia: Do you think the climate is changing? Make sure you support your idea with evidence and reasoning.

Olivia: I think the climate is changing (Claim) because this fall has been really warm (Evidence).

Mariela: Does being warm just one fall count as evidence for climate change?

Nate: No, climate is long term changes. It is just weather if it is one day or a month or a season (Reasoning). So I agree with Olivia that the climate is changing (Claim). But I think it is changing because the air temperature has slowly gotten warmer over a long time. The average temperature has increased like 2 degrees in the last 100 years (Evidence).

Physical Science Example

What is air?

Air is matter. I think air has mass because in the balloon experiment when we were comparing or weighting the deflated balloon to the balloon filled with air, the balloon filled with air weighted more. This is because of mass. Mass means the amount of matter in something. The balloon which had air in it has more mass. Another reason why I think air has mass is because in the syringe experiment, it was difficult to push the top of the syringe because the air was blocking it from going down. The tiny little molecules were trapped in a small space and created more pressure. Air pressure made it difficult to push down because the air takes up space. It is made of matter and has mass. It is true that air is made of matter and has mass.

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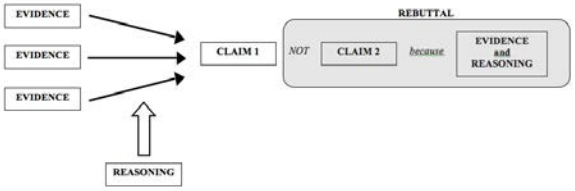
CER Framework *(McNeill & Krajcik, 2012)*



NRC Framework (2012)

- Explanations created through argumentation
  - "Deciding on the best explanation is a matter of argument that is resolved by how well any given explanation fits with all available data, how much it simplifies what would seem to be complex, and whether it produces a sense of understanding." (NRC, p. 68)
- Arguments can be about explanations, but also about other practices like models.
  - "arguments can be…about the best possible explanation. Argumentation is also needed to resolve questions involving, for example, the best experimental design, the most appropriate techniques of data analysis, or the best interpretation of a given data set" (NRC, p 71).

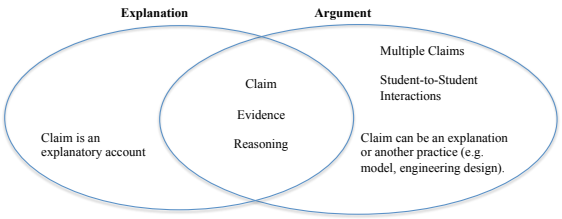
Explanation and Argument in NGSS

- **Explanation – End product of science**
  - Explanatory account (i.e. claim)
  - Evidence
  - Reasoning
- **Argument – Process**

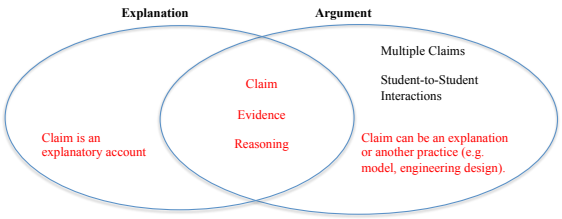
  Structure
  - Claim
  - Evidence
  - Reasoning

  Process
  - Students critique multiple claims (Multiple claims)
  - Students build off of and critique each others' ideas (Interactions)

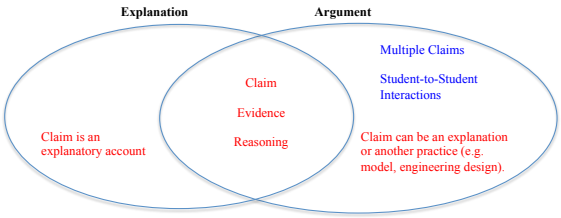
Explanation and Argument in NGSS



Explanation and Argument in NGSS

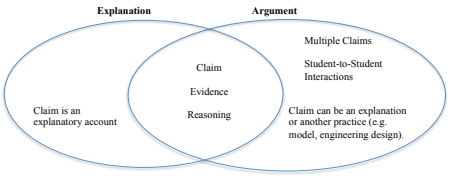


Explanation and Argument in NGSS



Revisit 6th grade Atacama Desert Example

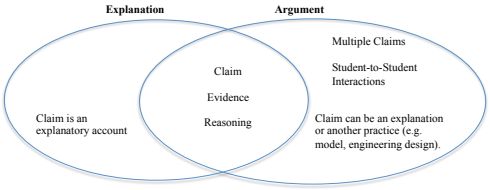
- Do you think explanation and argument are both occurring in this example? Why or why not?



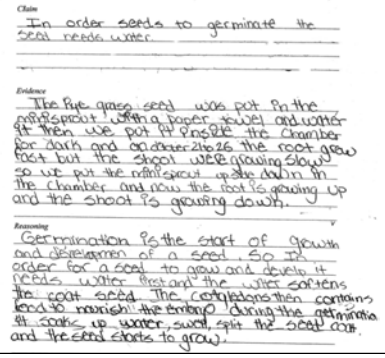
BREAK

CER in Explanation & Argument

- The claim, evidence and reasoning framework can support students in both explanation and argumentation.



Explanation – What causes seeds to germinate?


Claim

In order seeds to germinate the seed needs water.

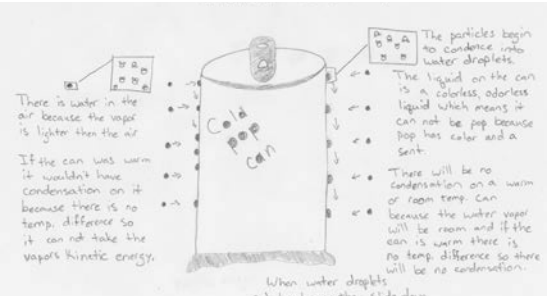
Evidence

The Pye grass seed was put in the mini sprout with a paper towel and water. It then we put it inside the chamber for dark and on other 26 to 26 the root grew fast but the shoot was growing slow so we put the mini sprout up side down in the chamber and now the root is growing up and the shoot is growing down.

Reasoning

Germination is the start of growth and development of a seed. So in order for a seed to grow and develo it needs water first and the water softens the coat seed. The cotyledons then contains food to nourish the embryo during the germinatio. It soaks up water, swell, split the seed coat and the seed starts to grow.

Argument – Model of Evaporation and Condensation



Argument – Model of Evaporation and Condensation

Amy	Wait guys! *Why do we think why condensation shows up*? Can anybody?
Amy	Yeah, but *why do you think it got there?…Because of the water in the air*?
Jenny	Because, *of the temperature…*
Amy	*The coldness is taking the kinetic energy from the air….*
Ivan	Coldness isn't a word.
Amy	…Okay, does everyone agree that the *kinetic energy is taking away from air and turning it into a liquid?*
Ivan	Sure.
Amy	We should write when kinetic energy…*when gas loses KE it turns into a liquid and when liquid loses KE it turns into a solid*……Or we could write gases minus KE of the liquid. Liquid minus KE equals……

Argument for an Explanation – What affects the water quality in our stream?

"My partner though that the reason the levels might be so bad is that there might be left over salt from last year. Well I don't have any solid evidence to contradict this theory, I do have critical thinking on my side. We were told that in pervious years of testing the results were much, much worse because it had already snowed and salt had already been put down on the parking lots. Since this year the levels were down so much *because* of the lack of salt, that makes me believe that any salt that may be left over isn't sufficient to affect it hat much, because if the salt really was affecting it drastically we would probably be getting closer results to what other testers have gotten in previous years."

Example Questions

- Explanation
  - What affects the speed an object falls?
  - How was the Grand Canyon formed?
  - Why did the majority of the Galapagos finches die in 1977?
- Argument
  - What is the best design for a solar powered car?
  - Where do you think the next earthquake is most likely to occur in the United States?
  - What model most accurately depicts how an odor travels across a room?

What causes some earthquakes to have more destructive power than others? How do you know?

- Data:

Location of Earthquake	Destructive Power at the Epicenter (center of the earthquake) (Scale: 0 to 12)	Average Yearly Crust Temperature 1 mile Below Surface (°F)	Hardness of Ground Material
Earthquake A	8	77	Soft
Earthquake B	8	65	Soft
Earthquake C	7	59	Hard
Earthquake D	6	53	Hard
Earthquake E	5	51	Very Hard

- Main Science Ideas:
  - Earthquakes travel through the Earth in waves. The waves begin at the focus, which is where the earthquake starts underground.
  - The epicenter is directly above the focus on the Earth's surface.
  - More powerful earthquakes happen when the focus of the earthquake occurs in soft ground material, because the earthquake waves can travel more easily through soft ground.

Activity 3: Examine Student Writing

- Working with someone at your table:

1. For each of the 4 examples:
   1. Circle the claim
   2. Number the pieces of evidence
   3. Underline the reasoning
2. Rank the four samples of student work from strongest (1) to weakest (4) considering the quality of the CER components.
3. Describe the criteria you used to rank the student writing.

Strategies to Design Lessons

- Developing a "good" question
  - Application of CER framework
  - Considering whether it is an explanation or an argument
- Choosing the activity structure
  - Examples – Written conclusion for a lab, Card sort activity, Reading & critiquing arguments and Science Seminar
- Designing scaffolds
  - Examples – Writing scaffolds, Discussion prompts and Graphic organizers

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Writing a "good" CER question

- Identifying opportunities for CER:
  - Consider what data the students can use as evidence
  - Consider what scientific principles (e.g. core ideas) the students can apply to make sense of the data
- Writing the CER question
  - Consider the clarity of the question – is it clear what claims the students could respond with

Explanation or Argument?

- Explanation
  - Focuses on how or why a phenomenon occurs
  - Could include the cause of a phenomenon
- Argument
  - The claim could be about – an explanation, a model, a engineering solution, etc.
  - Includes multiple potential claims
  - Provides an opportunity for students to build off of and critique each others' ideas

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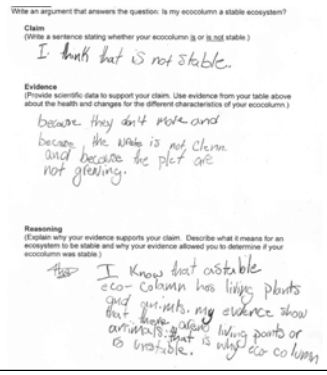
Conclusion for Lab



Write an argument that answers the question: Is my ecocolumn a stable ecosystem?

Claim
(Write a sentence stating whether your ecocolumn is or is not stable.)

I think that is not stable.

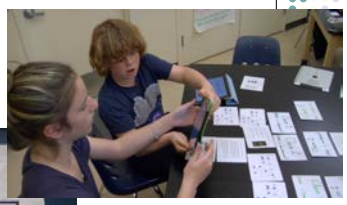
Evidence
(Provide scientific data to support your claim. Use evidence from your table above about the health and changes for the different characteristics of your ecocolumn.)

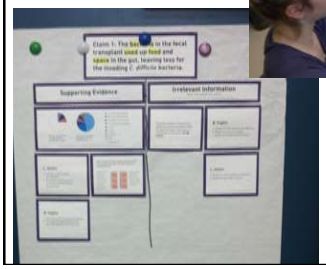
because they don't make and
because the water is not clean.
and because the plat are
not growing.

Reasoning
(Explain why your evidence supports your claim. Describe what it means for an ecosystem to be stable and why your evidence allowed you to determine if your ecocolumn was stable.)

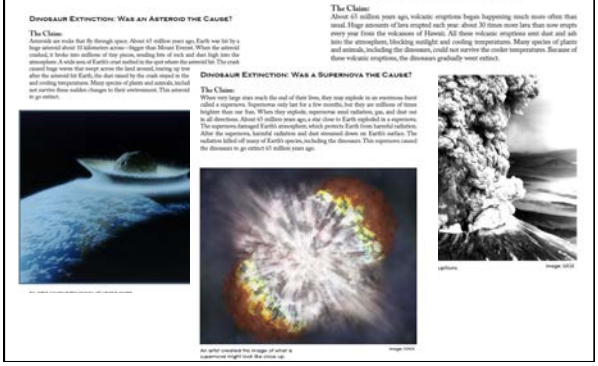
I Know that a stable
eco- column has living plants
and animals. my evidence show
that there are living points or
is not stable. that is why eco- column

Card Sort Activity





Reading & Critiquing Arguments



Dinosaur Extinction: Was an Asteroid the Cause?

The Claim:
Asteroids are rocks that fly through space. About 65 million years ago, Earth was hit by a large asteroid about 10 kilometers across—bigger than Mount Everest. When the asteroid crashed, it broke into millions of tiny pieces, sending lots of rock and dust high into the atmosphere. A wide area of Earth's crust melted in the spot where the asteroid hit. The crash caused huge waves that swept across the land around, tearing up tree after the asteroid hit Earth, the dust raised by the crash stayed in the and cooling temperatures. Many species of plants and animals, includ not survive these sudden changes to their environment. This asteroid to go extinct.

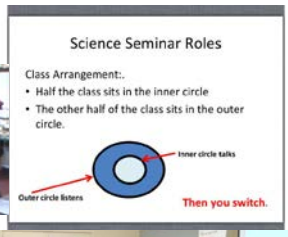
Dinosaur Extinction: Was a Supernova the Cause?

The Claim:
When very large stars reach the end of their lives, they may explode in an enormous burst called a supernova. Supernovas only last for a few months, but they are millions of times brighter than our Sun. When they explode, supernovas send radiation, gas, and dust out in all directions. About 65 million years ago, a star close to Earth exploded in a supernova. The supernova damaged Earth's atmosphere, which protects Earth from harmful radiation. After the supernova, harmful radiation and dust streamed down on Earth's surface. The radiation killed off many of Earth's species, including the dinosaurs. This supernova caused the dinosaurs to go extinct 65 million years ago.

Dinosaur Extinction: Were Volcanic Eruptions the Cause?

The Claim:
About 65 million years ago, volcanic eruptions began happening much more often than usual. Huge amounts of lava erupted each year: about 30 times more lava than now erupts every year from the volcanoes of Hawaii. All these volcanic eruptions sent dust and ash into the atmosphere, blocking sunlight and cooling temperatures. Many species of plants and animals, including the dinosaurs, could not survive the cooler temperatures. Because of these volcanic eruptions, the dinosaurs gradually went extinct.

Science Seminar



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- Designing scaffolds
  - Examples – Writing scaffolds, Discussion prompts and Graphic organizers

Writing Scaffolds

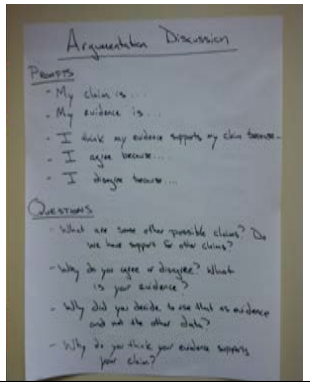
Conclusion:
Write an argument that answers the question: Which bird beak is the best adaptation for this environment?

Claim
[Write a sentence stating which beak is the best adaptation for this environment.]

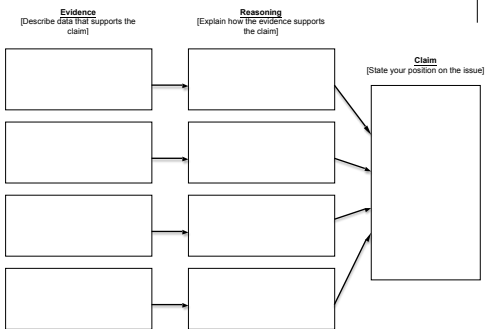
Evidence
[Provide scientific data to support your claim. The evidence should include the amount of food (marbles, pennies, popsicle sticks & red water) that the beaks ate.]

Reasoning
[Explain why your evidence supports your claim. Describe what an adaptation is and why your evidence allowed you to determine the beak was the best adaptation.]

Discussion Prompts



Graphic organizer



Activity 4: Redesign a science lesson

- Read vignette of a middle school science lesson
- With someone at your table discuss how you would redesign this lesson:
  1. How could you redesign the lesson to focus more on explanation?
  2. How could you redesign the lesson to focus more on argument?
  3. Do you think it could be redesigned to effectively focus on both practices?
     - If yes, how? If no, why not?

Conclusions

- An explanation focuses on how or why a phenomenon occurs.
- An argument can include a variety of different types of claims (model, design, explanation), but includes multiple potential claims and the opportunity to build off of and critique the ideas of others.
- The CER framework can help support both scientific practices.
- Engaging in these scientific practices is challenging and requires multiple opportunities and different types of support for students.

Contact Information

- Kate's e-mail – kmcneill@bc.edu
- Maria's e-mail - maria.gonzalez.7@bc.edu

http://www.katherinelmcneill.com

- Workshops
  - Has the powerpoint
- Teaching Resources
  - Links to other webpages (e.g. CER assessments, lessons, etc.)