

Designing classrooms for science practices:

Strategies from research on scientific argumentation

Katherine L. McNeill, Boston College

Outline

- Science as a set of practices
  - Video from 2nd Grade classroom
- What is an argument in a science classroom?
  - Define argument
  - Examples of students' written arguments
  - Video of argument in a kindergarten classroom
  - Video of argument in a 7th grade classroom
- How do we support argument in a science classroom?
  - Developing a good question
  - Choosing the activity structure
  - Designing scaffolds

Powerpoint – www.katherinelmcneill.com (Presentations)

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Science Practices: A shift in science education

- Historically, science education has overemphasized students learning a myriad of facts rather than understanding how ideas are developed and transform over time (Roth & Garnier, 2006).
- "Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge. Both elements – knowledge and practice – are essential" (NRC, 2012, p. 26).

Science Practices: What are they?

- "We use the term 'practices' instead of a term such as 'skills' to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice." (NRC, 2012)
- 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

Science Practices: 3 Potential Challenges

- Actively engage students
  - Students need to actively engage in the practices, not just observe their teachers engage in the practices (NRC, 2012).
- Integrate practice and content
  - The practices and disciplinary core ideas need to be integrated coherently in curriculum, instruction and assessment (NRC, 2012).
- Not everything is a practice
  - The term "inquiry" has been used in many different ways (NRC, 2012), the same concern potentially exists with practices, such as argumentation (McNeill, et al., 2013).

2nd Grade Science Lesson

- Are any of the science practices included in this introduction to the lesson? If yes, which ones and why?
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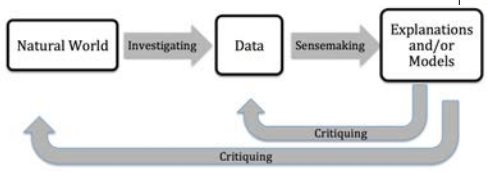
8 Science Practices:
Why argument?



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

8 Science Practices:
Why argument?

Argument has traditionally not played a key role in science classrooms.

Argumentation plays an essential role in the development, critique and revision of explanations and models in science.

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

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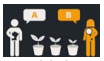
Argument from Evidence

Structure

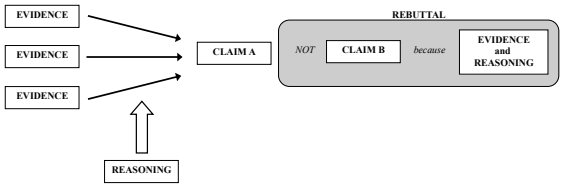
- Claim – Provides a conclusion or solution
- Evidence – Scientific data such as measurements or observations
- Reasoning – Explains why the evidence supports the claim

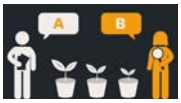


Process

- Multiple Claims – Students compare and critique multiple claims
- Student Interactions through critique – Students pose and respond to questions to challenge ideas and resolve conclusions

CER Framework (McNeill & Krajcik, 2012)





Physics Example

Does a lever make work easier?

Levers sometimes make work easier. (Claim) When we picked up the load without the lever, it was 2.2 N. When the load was 5.0 cm from the fulcrum and the effort was 10 cm from the fulcrum, it was 0.8 N. When the load was 20 cm from the fulcrum and the effort was 10 cm from the fulcrum, it was 4.3 N. When the load was 10 cm from the fulcrum and the effort was 5.0 cm, it was 5.3 N. When the load was 10 cm from the fulcrum and the effort was 20 cm, it was 1.3 N (Evidence) Doing work is the ability to move an object. If it takes less force, the work is easier. A lever can make work easier depending on the position of the fulcrum, effort and load. When the fulcrum is close to the load and far from the effort, the work is easier. (Reasoning)

Physics 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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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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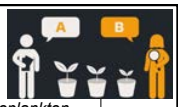

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Environmental Science

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."

Environmental Science Example

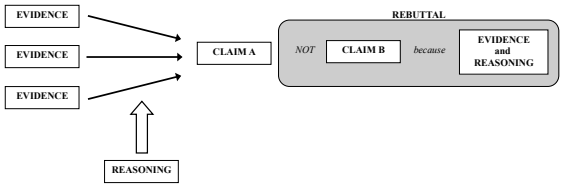
Mr. Garcia: Do you think the climate is changing? Make sure you support your idea with evidence and reasoning.

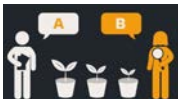
Olivia: I think the climate is changing (Claim) because this fall has been really warm (Evidence).

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).

CER Framework (McNeill & Krajcik, 2012)





Kindergarten Example

Kindergarten Lesson Focus:

- Question: How are all the sounds made?
- Evidence: Students engage in investigations examining how sound is produced
- Activity: Classroom discussion
  - Teacher records claim and 3 pieces of evidence

Questions to Consider for CER structure and process:

- What are the strengths and challenges in terms of the student talk?
- How did the teacher support the student discussion?
  - What are some aspects that she did well?
  - What are some areas in which she could improve?

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(Zembal-Saul, McNeill & Hershberger, 2013)

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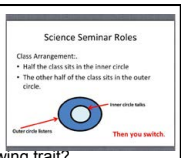

7th Grade Lesson Focus:

- Context: Heredity Unit
- Question: What kind of allele causes the glowing trait?
- 3 Possible Claims
  - The allele for fluorescence is dominant.
  - The allele for fluorescence is non-dominant.
  - The allele for fluorescence is incompletely dominant.
- Evidence: Punnett squares of different crosses of the cats. Data about crosses from jelly fish.
- Activity: Science Seminar

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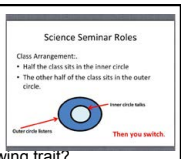

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Strategies to Design Lessons

- Developing a "good" question
  - Consider whether the CER structural and process elements
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  - Examples – Written conclusion for a lab, Card sort activity, Reading & critiquing arguments, Group work with different claims, and Science Seminar
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  - Examples – Writing scaffolds, Discussion prompts, and Graphic organizers

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Writing a "good" question

- Consider the structure
  - Includes data the students can use as evidence
  - Potentially provides opportunities to apply disciplinary core ideas
- Consider the process
  - Includes multiple potential claims
  - Provides an opportunity for students to build off of and critique each others' ideas
- Consider the clarity of the question
  - Is it clear what claim the student should respond with?

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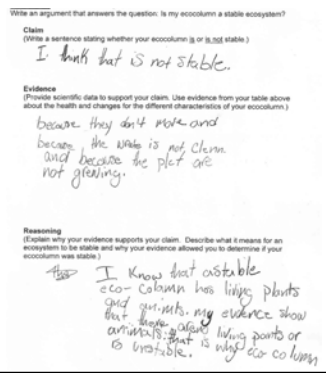
Conclusion for Lab



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.

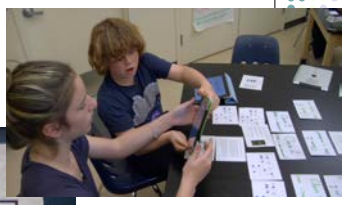
Evidence
(Provide scientific data to support your claim. Use evidence from your table above about the health and changes for the different characteristics of your ecocolumn.)

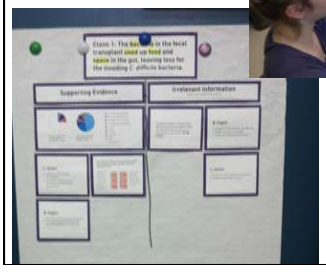
because they don't move and because the water is not clean. and because the plot are not growing.

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 aren't any living plants or animals. that is why eco column is unstable.

Card Sort Activity





Reading & Critiquing

DINOSAUR EXTINCTION: WAS AN ASTEROID THE CAUSE?

The Claim:

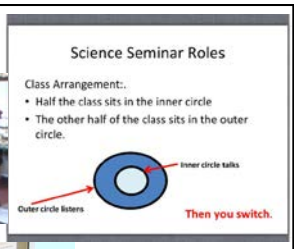
DINOSAUR EXTINCTION: WAS A SUPERNOVA THE CAUSE?

The Claim:

DINOSAUR EXTINCTION: WERE VOLCANIC ERUPTIONS THE CAUSE?

The Claim:

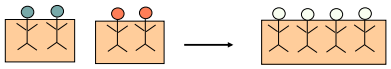
Science Seminar



Group Work With Different Claims

- Goal is to engineer a situation where students in a group have different claims, which encourages them to question and critique each other's claims

Example Approach:



- **Argument Jigsaw:** 2 pairs of students converge to agree on a single explanation or model

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Writing Scaffolds

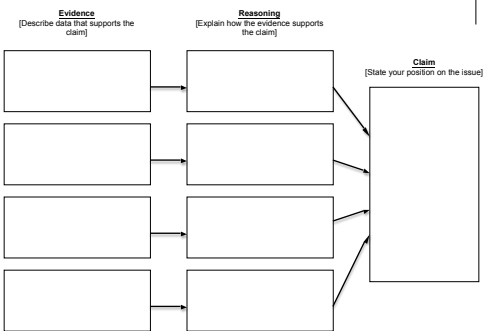
Conclusion:
Write an argument that answers the question: Which bird beak is the best adaptation for this environment?

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

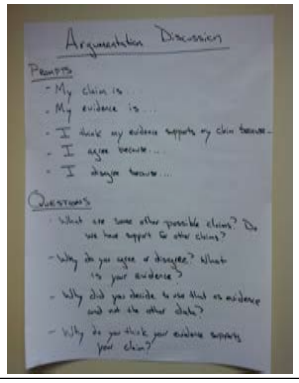
Evidence
[Provide scientific data to support your claim. The evidence should include the amount of food (marbles, pennies, popsicle sticks & red water) that the beaks ate.]

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.]

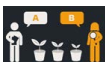
Graphic organizer



Discussion Prompts



Conclusions



- The focus on science practices is an exciting but challenging time.
- Students need support to actively engage in these practices while they are simultaneously applying and developing stronger understandings of disciplinary core ideas.
- Argument includes both a structural component (CER) and a process element (student-to-student interactions in which they critique claims).
- By providing students with a variety of activity structures and supports they can develop greater proficiency in argumentation over time.

Contact Information

- Kate McNeill
  - e-mail – kmcneill@bc.edu

- Thanks to the National Science Foundation
  - *Constructing and Critiquing Arguments in Middle School Science Classrooms,* DRL-1119584.
  - *Instructional Leadership for Scientific Practices*, DRL-1415541.

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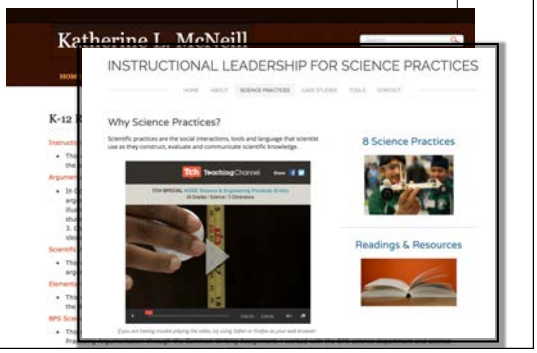

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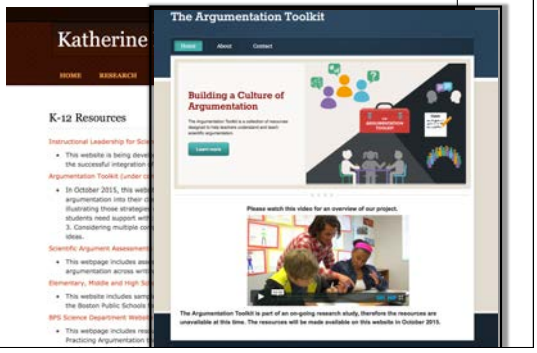

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