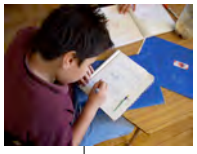




Demystifying data through claims, evidence and reasoning:

Bridging the gap between elementary science and literacy

Katherine L. McNeill
Boston College

Dean Martin
Gardner Pilot Academy

Overview of Session

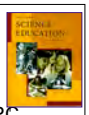
- Introduce Scientific Argumentation
- Conduct Lever Investigation
- Analyze Student Writing
- Discuss Common Student Difficulties and Teaching Strategies

Importance of Scientific Argumentation

- Science is a social process in which scientists debate knowledge claims and continuously refine and revise knowledge based on evidence
- Students should generate and evaluate scientific evidence and arguments
- Change students' image of science
- Enhance students' scientific reasoning abilities
- Foster deeper understanding of important science concepts



National Science Standards

- Use data to construct a reasonable explanation (NRC, A1/D)
- Communicate investigations and explanations (NRC, A1/E)
- Seek reasons for believing something rather than just claiming "Everybody knows that…" or "I just know" and discount such claims when made by others. (AAAS,12E/E3*)
- *Inquiry and the National Science Education Standards* (NRC, 2000)
  1. Engaging in scientifically-oriented questions
  2. Giving priority to evidence
  3. Formulating explanations from evidence
  4. Connecting explanations to scientific knowledge
  5. Communicating and justifying explanations.

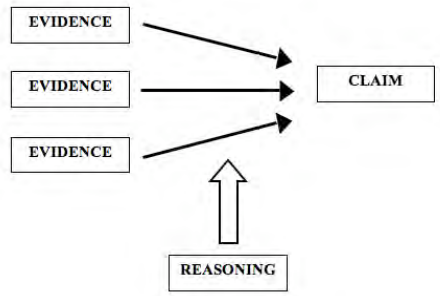
Framework for Scientific Argument

Adapted from Toulmin (1958)

- **Claim**
  - a conclusion about a problem
- **Evidence**
  - scientific data that supports the claim
- **Reasoning**
  - a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles

Framework for Scientific Argument

Adapted from Toulmin (1958)



Physics Example

Does mass affect how quickly an object falls?

No, mass does not affect how quickly an object falls. (Claim) In the investigation, 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 to fall, I know that mass does not affect how quickly something falls. (Reasoning)

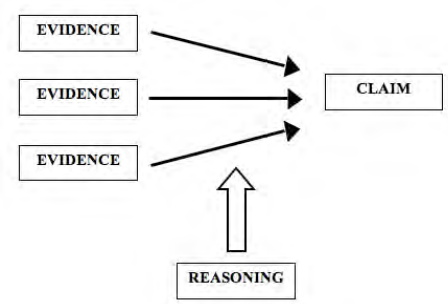
Biology Example

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) All of the other organisms in the food web depend on the phytoplankton, even if they do not directly eat them. Organisms are affected by other organisms in a food web even if they are not directly linked to them. (Reasoning)

Framework for Scientific Argument

Adapted from Toulmin (1958)



Lever Investigation

- With your group, you are going to conduct two lever investigations to answer the question: Does a lever make work easier?
- Conduct the investigation and record the data in your data table and on the graph.
- After you are finished collecting data, write a scientific argument that addresses the question: Does a lever make work easier?

Activity: Assessing Students' Writing

- Record responses to the questions on chart paper.
- Score the student response using the specific rubric. Give them a separate score for:
  - Claim - 0, 1 or 2
  - Evidence - 0, 1, 2, or 3
  - Reasoning - 0, 1, 2, or 3
- Provide feedback and strategies
  - What feedback would you provide this student? Why would that feedback be helpful?
  - What strategies might you use to help this student construct a stronger explanation?

Base or Generic Rubric

		Claim *A statement or conclusion that answers the original question/problem.*	**Evidence** *Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.*	**Reasoning** *A justification that connects the evidence to the claim. It shows why the data counts as evidence by using appropriate and sufficient scientific principles.*
LEVEL	0	Does not make a claim, or makes an inaccurate claim.	Does not provide evidence, or only provides inappropriate evidence (Evidence that does not support claim).	Does not provide reasoning, or only provides inappropriate reasoning.
	VARIES FROM 1 to 3	Makes an accurate but incomplete claim.	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides reasoning that connects the evidence to the claim. May include some scientific principles or justification for why the evidence supports the claim, but not sufficient.
		Makes an accurate and complete claim.	Provides appropriate and sufficient evidence to support claim.	Provides reasoning that connects the evidence to the claim. Includes appropriate and sufficient scientific principles to explain why the evidence supports the claim.

Activity: Assessing Students' Writing

- Record responses to the questions on chart paper.
- Score the student response using the specific rubric. Give them a separate score for:
  - Claim - 0, 1 or 2
  - Evidence - 0, 1, 2, or 3
  - Reasoning - 0, 1, 2, or 3
- Provide feedback and strategies
  - What feedback would you provide this student? Why would that feedback be helpful?
  - What strategies might you use to help this student construct a stronger explanation?

Student Difficulties

- Students have difficulty articulating and justifying their claims (Sadler, 2004).
- Difficulties with evidence
  - Difficulty using appropriate evidence (Sandoval, 2003)
  - Use their own intuitive beliefs, experiences or opinions, as evidence instead of scientific data (Hogan & Maglienti, 2001).
  - Difficulty providing sufficient evidence (Sandoval & Millwood, 2005).

Student Difficulties

- Difficulties with reasoning
  - Difficulty providing backing or reasoning for why evidence supports the claim (Bell & Linn, 2000).
  - Difficulty using scientific principles to explain why their evidence supports their claim (McNeill & Krajcik, 2006).

Instructional Strategies

1. Make the framework explicit ⇨
2. Connect to everyday arguments ⇨
3. Discuss the rationale behind ⇨ argumentation
4. Model the construction of arguments ⇨
5. Provide multiple opportunities
6. Provide students with feedback ⇨
7. Have students critique arguments ⇨

Conclusion

- Scientific argumentation is an essential part of science that is challenging for students
- Make the scientific argumentation framework explicit (claim, evidence, and reasoning)
- Provide prompts or scaffolds for student writing
- Use instructional strategies in your teaching
  - Connect to everyday arguments
  - Discuss the rationale behind argumentation
  - Model the construction of arguments
  - Provide students with feedback
  - Have students critique arguments

More Information

- Kate's Contact information
  - kmcneill@bc.edu
  - www.katherinelmcneill.com
- Dean's Contact information
  - anderson.martin@netzero.net

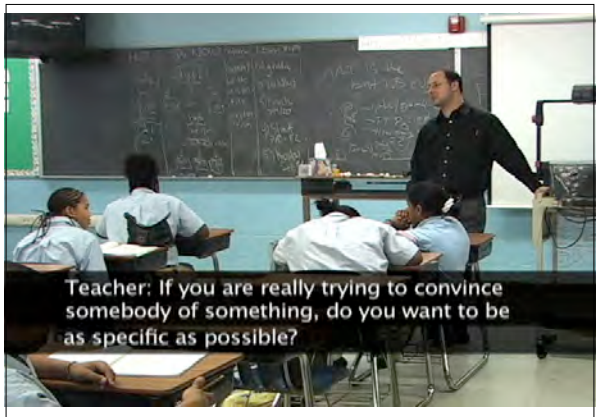
- Thanks to Many
  - Numerous teachers and students
  - Colleagues from Boston College, the University of Michigan and Northwestern University
  - National Science Foundation
    - Investigating and Questioning our World through Science and Technology (IQWST) (ESI-0101780 & ESI-0439352)
    - Center for Curriculum Materials in Science (CCMS) (ESI-0227557)
    - Supporting Grade 5-8 Students in Writing Scientific Explanations project (DRL 0836099)

Hyperlinked Videos

Discuss the Framework

Connect to Everyday Examples

Connect to Everyday Examples



Providing Students With Feedback

Have Students Engage in Peer Critique

Can you create the strongest argument?

Question:

How can you design a car to go the fastest?

CLAIM
Circle ONE of the following.

A. My car will go the fastest, because I will make it really strong.
B. The car with the lightest load being pulled by the largest force will go the fastest.
C. How fast a car goes is determined by how far it travels in a certain time.

EVIDENCE
Circle TWO of the following.

A. The car with only one block on the car took 1 second to travel across the table while the car with three blocks took 3 seconds.
B. We always built our cars carefully and they traveled really fast.
C. Car companies, like Ford, try to build light cars because they will travel faster.
D. The car that was pulled by 5 washers took 2 seconds to travel across the table while the car with 1 washer took 7 seconds.
E. Our group had a lot of fun building and testing our cars, except for the one day that our car kept breaking.
F. Our experiments showed that light cars travel faster.

REASONING
Circle ONE of the following.

A. The data from our experiments shows us how to build our car. Since the data shows that fast cars have a light load and fast cars are pulled by a large force then this is how we should build our car.
B. Since car companies and race cars have cars that are really light and have large engines this means we should design our car in the same way. It should have a light load and be pulled by a large force.
C. The speed was determined by how many seconds it took for the car to travel across the table. The car with less blocks had a lighter load and it traveled faster. The car that was pulled by more washers was pulled by a greater force and it traveled faster.