



Supporting k-12 students in arguments across reading, writing and talking

Katherine L. McNeill
Boston College

Pam Pelletier, Dean Martin & Nancy Blasi
Boston Public Schools



Agenda



- Overview and Introductions
- Discussion: Argument across disciplines & life
- Presentation: Introduction to argument
- Activity 1: Analyze classroom video (talking)
- Activity 2: Planets investigation (talking, listening, writing)
- *Break*
- Activity 3: Dinosaur extinction (reading)
- Activity 4: Analyze student writing – rubrics (writing)
- Conclusions and Discussion

Powerpoint - <http://www.katherinelmcneill.com/workshops.html>

Introductions



- Participant Backgrounds
 - Elementary school teachers?
 - Middle school teachers?
 - High school teachers?
 - Science coordinator/administrators?
 - Curriculum developers?
 - University faculty members?
 - Other?

Discussion - Argument



- What do you see as the similarities and differences between argument in science, in other subjects (e.g. ELA) and in everyday life?

Common Core ELA Standards



- Grades 11-12 students (Writing):
 - Write arguments focused on *discipline-specific content*. - Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons and evidence.
- Grades 11-12 students (Reading):
 - Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.
- Grades 11-12 students (Talking and Listening)
 - Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

Next Generation Science Standards (NGSS, Appendix F)



- Grade 9-12 Students
 - Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
 - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
 - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.

Next Generation Science Standards (NGSS, Appendix F)



- Grade 9-12 Students
 - Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. *Reading & Listening*
 - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. *Writing & Talking*
 - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. *Writing & Talking*

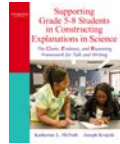
Next Generation Science Standards (NGSS, Appendix F)



- Grade 9-12 Students
 - Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
 - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
 - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.

CER Framework

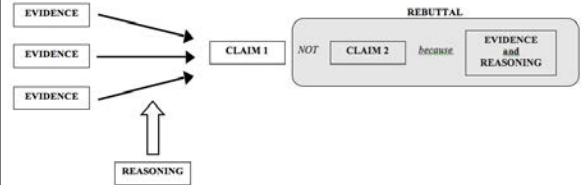
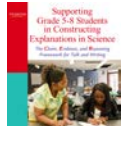
(McNeill & Krajcik, 2012)



- **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 and 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)

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) You might think the shark population would not change, because they do not eat the phytoplankton. But they will actually die out because they eat organisms that eat organisms that eat the phytoplankton. (Rebuttal)

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.

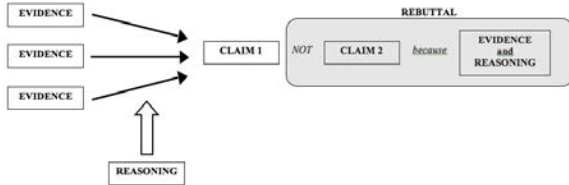
Physical Science Example



What is air?

Air is matter. (Claim) 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 (Evidence) This is because of mass. Mass means the amount of matter in something. The balloon which had air in it has more mass. (Reasoning) 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 (Evidence). 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 (Reasoning).

CER Framework (McNeill & Krajcik, 2012)



Argumentation Goals

- Argument Structure (CER)
 - Use high quality evidence
 - Explain their reasoning for why the evidence supports the claim
- Argumentation Process
 - Students consider multiple claims as they try to determine the strongest claim (multiple claims)
 - Students talk directly to each other as they question, critique and revise different ideas (student interactions through critique)

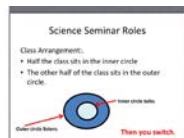
Activity 1: Analyze Classroom Video (talking)

- Watch 5 minute videoclip of classroom talk
- 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 he did well?
 - What are some areas in which he could improve?
- What does it take to build a classroom culture of argumentation?

Activity 1: Video from 7th Grade Classroom



- Context: Heredity Unit (Lawrence Hall of Science, 2014)
- Question: What kind of allele causes the glowing trait in the cats?
- 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 cats.
 - Data about crosses from jelly fish.
- Activity: Science Seminar



Activity 1: 7th Grade Example



Activity 1: Analyze Classroom Video (talking)



- Watch 5 minute videoclip of classroom talk
- 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 he did well?
 - What are some areas in which he could improve?
- What does it take to build a classroom culture of argumentation?

Supporting Argumentation Discussions



1. **Appropriate Question**
 - Need a question where there are multiple possible claims for students to discuss
2. **Student Roles**
 - When introducing the activity, be explicit about the students' roles and how they should be talking to each other.
3. **Sentence Starters**
 - Post sentence starters and questions to help them get started
4. **Wait Time**
 - Use wait time and remove yourself from the conversation (e.g. take notes) so they focus on each other.

Activity 2: Planets Investigation (writing & talking)



- How many planets are in the solar system?
- **BRAINSTORM**
 - With your group, brainstorm criteria or evidence you would use to determine whether an object in the sky is a planet.

Activity 2: Planets Investigation (writing & talking)



- How many planets are in Table 1?
- Write an Argument
 - With your table, write an argument making a claim about how many planets you think are in Table 1. Provide evidence and reasoning for your claim.
- Debate
 - Groups will share their claims, provide their evidence for their claims, question and critique the claims of their peers.
 - Our goal is to revise our ideas based on evidence and critique. We want to think about as a group – *which criteria are most important? Why?*

Activity 2: Planets (writing & talking)



Object	Orbits	Distance from the Sun (AU)*	Shape	Diameter (km)	Moons	Orbit Shape	Orbital Zone Clear of Other Objects?
A	The Sun	.4	Round	4,879	0	Elongated	Yes
B	The Sun	2.9	Round	950	0	Circular	No
C	The Sun	3.0	Irregular	54	1	Circular	No
D	The Sun	3.4	Irregular	570	0	Elongated	No
E	The Sun	5.4	Round	142,984	63	Circular	Yes
F	Object E	5.4	Round	5,262	0	Circular	No
G	The Sun	10.1	Round	120,536	60	Circular	Yes
H	The Sun	49.3	Round	2,390	3	Elongated	No
I	The Sun	97.5	Round	2,697	1	Elongated	No
J	The Sun	975.6	Round	1,800	0	Elongated	No

*Note: AU = Astronomical unit is a unit of length equal to exactly 149, 597, 870, 700 meters or approximately the mean Earth-Sun distance.

Our goal is to revise our ideas based on evidence and critique. We want to think about as a group – *which criteria are most important? Why?*

Activity 2: Planets Investigation (writing & talking)



- How many planets are in Table 1?
- Write an Argument
 - With your table, write an argument making a claim about how many planets you think are in Table 1. Provide evidence and reasoning for your claim.
- Debate
 - Groups will share their claims, provide their evidence for their claims, question and critique the claims of their peers.
 - Our goal is to revise our ideas based on evidence and critique. We want to think about as a group – *which criteria are most important? Why?*

Activity 2: Planets (writing & talking)



Object	Orbits	Distance from the Sun (AU)*	Shape	Diameter (km)	Moons	Orbit Shape	Orbital Zone Clear of Other Objects?
A – Mercury	The Sun	.4	Round	4,879	0	Elongated	Yes
B – Ceres	The Sun	2.9	Round	950	0	Circular	No
C – Ida	The Sun	3.0	Irregular	54	1	Circular	No
D – Pallas	The Sun	3.4	Irregular	570	0	Elongated	No
E – Jupiter	The Sun	5.4	Round	142,984	63	Circular	Yes
F - Ganymede	Jupiter	5.4	Round	5,262	0	Circular	No
G – Saturn	The Sun	10.1	Round	120,536	60	Circular	Yes
H – Pluto	The Sun	49.3	Round	2,390	3	Elongated	No
I – Eris	The Sun	97.5	Round	2,697	1	Elongated	No
J - Sedna	The Sun	975.6	Round	1,800	0	Elongated	No

*Note: AU = Astronomical unit is a unit of length equal to exactly 149, 597, 870, 700 meters or approximately the mean Earth-Sun distance.

Argumentation Goals

- Argument Structure (CER)
 - Use high quality evidence
 - Explain their reasoning for why the evidence supports the claim
- Argumentation Process
 - Students consider multiple claims as they try to determine the strongest claim (multiple claims)
 - Students talk directly to each other as they question, critique and revise different ideas (student interactions through critique)

Discussion

- If you engaged your students in this type of activity, what do you envision would occur?
- What are the strengths and challenges for your students when engaged in this type of talking, listening and writing?
- What does it take to build a classroom culture of argumentation?

BREAK



Activity 3: Dinosaur Extinction (reading)

- Read the 3 scientific arguments that offer different claims for the question: *What caused the dinosaur extinction?* (Lawrence Hall of Science, 2012)
- Record ideas about the claim and evidence for the 3 arguments on 1 side of the handout (15 min).
- Discuss with a colleague your responses (15 min)
 - Is the evidence for each claim appropriate and sufficient? Why or why not?
 - Which claim do you find most convincing? Why?

Activity 3: Dinosaur Extinction (reading)



- Discussion
 - Which claim did you find most convincing? Why?
 - Is the evidence for each claim appropriate and sufficient? Why or why not?
 - What strategies did you use to analyze the text?
 - What does it take to build a classroom culture of argumentation?

Activity 4: Analyze student writing (McNeill & Martin, 2011)



- Students can have difficulty writing arguments that use the CER structure – instead they can provide a personal story or informational text.
- After developing an initial understanding of the CER structure, they can still have challenges
 - Providing appropriate evidence
 - Explaining their reasoning for why the evidence supports the claim

Activity 4: Base Argumentation Rubric




	Claim	Evidence	Reasoning	Rebuttal
	A statement or conclusion that answers the original question/problem.	Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	A justification that connects the evidence to the claim. It shows why the data counts as evidence by using appropriate and sufficient scientific principles.	Recognizes and describes alternative explanations, and provides counter evidence and reasoning for why the alternative explanation is not appropriate.
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.	Does not recognize that alternative explanation exists and does not provide a rebuttal or makes an inaccurate rebuttal.
LEVELS	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.	Recognizes alternative explanations and provides appropriate but insufficient counter evidence and reasoning in making a rebuttal.
FORM	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.	Recognizes alternative explanations and provides appropriate and sufficient counter evidence and reasoning when making rebuttals.
1 to 5				

Activity 4: Adapting the base for a specific rubric



- Try writing an “ideal” student response.
 - After you have given the item to students, also look at their writing to revise the rubric.
- Components
 - How many components are required for the response (CE, CER or CERR)?
- Quality of Components
 - For each of the components, what is the range of quality the students responses could include (i.e. how many levels)?



LEVER EXPERIMENT

- Students use a lever and a spring scale to measure the effort needed to lift a load when:
 - The position of the load remains constant and the position of the effort changes
 - The position of the effort remains constant and the position of the load changes
- Students can use their data to support the claim – A lever sometimes makes work easier.

This investigation is part of the FOSS Levers and Pulleys Module © The Regents of the University of California. Can be duplicated for classroom or workshop use. Investigation 1: Levers

Activity 4: Does a lever make work easier?

	Claim	Evidence	Reasoning
	<i>A statement or conclusion that answers the original question/problem.</i>	<i>Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.</i>	<i>A justification that connects the evidence to the claim. It shows why the data counts as evidence by using appropriate and sufficient scientific principles.</i>
0	Does not make a claim, or makes an inaccurate claim like – “Levers do not effect work.”	Does not provide evidence, or only provides inappropriate evidence or vague evidence, like “the data shows me it is true” or “It would be a lot harder to move a piano without a lever”	Does not provide reasoning, or only provides inappropriate reasoning like “levers are used in lots of ways in our lives”.
1	Makes an accurate but vague or incomplete claim like – “Levers make work easier.” Or “Levers do not make work easier.” (It can actually depend).	Makes a general statement about how in the investigations levers sometimes made the work easier and sometimes did not make the work easier. Does not include specific data.	Provides 1 of the following 2 reasoning components: <ol style="list-style-type: none"> A lever can make work easier depending on the position of the fulcrum, effort and load. Doing work is the ability to move an object. If it takes less force, the work is easier.
2	Makes an accurate and complete claim like – “Levers sometimes make work easier.”	Provides 1 of the following 2 pieces of evidence: <ol style="list-style-type: none"> Specific data (e.g. numbers) from the investigation when the lever made the work easier. Specific data (e.g. numbers) from the investigation when the lever made the work harder. 	Provides all 2 reasoning components: <ol style="list-style-type: none"> A lever can make work easier depending on the position of the fulcrum, effort and load. Doing work is the ability to move an object. If it takes less force, the work is easier.
3		Provides 2 of the following 2 pieces of evidence: <ol style="list-style-type: none"> Specific data (e.g. numbers) from the investigation when the lever made the work easier. Specific data (e.g. numbers) from the investigation when the lever made the work harder. 	

Activity 4: Analyzing Student Writing - Rubrics

- Score the 3 student responses using the specific rubric. For each student give them a separate score for:
 - Claim - 0, 1 or 2
 - Evidence - 0, 1, 2, or 3
 - Reasoning - 0, 1, or 2
- Provide feedback and strategies
 - What feedback or strategies would you use with these students?
 - What does it take to build a classroom culture of argumentation?

Conclusions

- Argumentation is an important goal in current ELA and science standards documents.
- Argumentation includes both a focus on:
 - CER structure
 - Argumentation as a process
- Focusing on argumentation across writing, talking, listening and reading can help students develop greater expertise
- Developing expertise in argumentation requires the use of multiple strategies to develop a classroom culture of argumentation

Contact Information



- Kate's e-mail – kmcneill@bc.edu
- Pam's e-mail – ppelletier@bostonpublicschools.org
- Dean's e-mail – dean.bpsscience@gmail.com

- Kate's website

- <http://www.katherinelmccneill.com>

- Thanks to -

- National Science Foundation - *Constructing and Critiquing Arguments in Middle School Science Classrooms*, DRL-1119584.
- Colleagues at the Lawrence Hall of Science, University of California Berkeley – Suzy Loper, Phaela Peck, and Traci Wierman

