



Supporting Students in Science Thinking and Writing

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Agenda

- Introductions
 - Activity - Chemistry Investigation
- Break*
- Presentation - Rationale & Framework
 - Watch and Discuss video of 7th grade classroom
- Lunch*
- Activity - Analyze student writing
 - Presentation - Student challenges
 - Presentation - Designing learning tasks
 - Activity - Design learning tasks
 - Logistics and Wrap-up



Introductions

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



Activity - Chemistry Investigation

With your group:

- Conduct investigation 7.1: What happens to properties when I combine substances?
 - Record observations before combining
 - Combine the substances
 - Record observations after combining



What do students know at this point?

- Matter is composed of atoms & molecules in constant motion.
- Substances can exist in solid, liquid, and gaseous states.
- Substances have characteristic properties that help identify substances and distinguish them from one another.
- Solubility, density, and melting point are properties of substances.
- Both baking soda and road salt are soluble in water (determined in a previous investigation).

Activity - Chemistry Investigation

- Conduct investigation 7.1: What happens to properties when I combine substances?
 - Record observations before combining
 - Combine the substances
 - Record observations after combining
- On a large piece of post-it paper with your group, write an ideal student response to the conclusion question.
 - Write a **scientific explanation** that states whether or not you think new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.

Activity - Chemistry Investigation

- Post ideal student responses on the wall.
- Discussion Questions:
 - What are the similarities and differences across what the different groups wrote?
 - What are some characteristics of strong scientific explanations?
 - What challenges do you think students have with this type of writing?

Break!



Scientific Explanations and Arguments

	Data				
	Color	Hardness	Solubility	Melting Point	Density
Fat	Off white or slightly yellow	Soft squishy	Water - no Oil - yes	~37° C	0.92 g/cm ³
Soap	Milky white	Hard	Water - yes Oil - no	Higher than 100° C	0.84 g/cm

Write a scientific explanation stating whether fat and soap are the same substance or different substances.

Brandon's First Explanation

↓ Fat and soap are both stuff, but they are different substances. Fat is used for cooking and soap is used for washing. They are both things we use everyday. The data table is my evidence that they are different substances. Stuff can be different substances if you have the right data to show it.

Brandon's Revised Explanation

Fat and soap are different substances. Fat is off white and soap is milky white. Fat is soft squishy and soap is hard. Fat is soluble in oil, but soap is not soluble in oil. Soap is soluble in water, but fat is not. Fat has a melting point of 37°C and soap has a melting point above 100°C. Fat has a density of 0.92 g/cm³ and soap has a density of 0.84 g/cm³. These are all properties. Because fat and soap have different properties, I know they are different.

Importance of Scientific Explanation and 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 explanations
- Aligns with reform documents focused on 21st century skills and k-8 science classrooms.
- Stressed in science education standards.



What are Explanation and Argumentation?



- **Explanation**
 - *make sense* of how or why a phenomenon occurred
 - Examples:
 - Explain why the biodiversity decreased
 - Explain what has happened to the pitch of bird song in cities
- **Argumentation:**
 - *Defend or support* knowledge claims through evidence, warrants and backing
 - Examples:
 - Argue for your explanation for why the biodiversity decreased
 - Argue for your experimental design to study what is happening to the biodiversity

National Science Standards



- Present a brief scientific explanation orally or in writing that includes a claim and the evidence and reasoning that supports the claim. (AAAS, 12D/M6**)
- Notice and criticize the reasoning in arguments in which the claims are not consistent with the evidence given (AAAS, 12E/M5b*)
- *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.

New Frameworks for K-12 Science Education



- “What engages *all* scientists, however, is a process of critique and argumentation. Because they examine each other’s ideas and look for flaws, controversy and debate among scientists are normal occurrences, neither exceptional nor extraordinary.”
- By grade 12, students should be able to:
 - Construct a scientific argument showing how the data support the claim.
 - Identify possible weaknesses in scientific arguments, appropriate to the students’ level of knowledge, and discuss them using reasoning and evidence.

New Frameworks for K-12 Science Education



- “Reading, interpreting, and producing text are fundamental practices of science in particular, and they constitute at least half of engineers’ and scientists’ total working time.”
- “Communicating in written or spoken form is another fundamental practice of science; it requires scientists to describe observations precisely, clarify their thinking, and justify their arguments.”
- Multiple modalities – reading, writing and talking

Common Core English Language Arts Standards

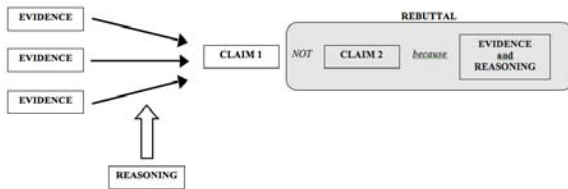
- Grades 11-12 students (Reading):
 1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.
- Grades 11-12 students (Writing):
 1. Write arguments focused 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 (Talking and Listening)
 1. 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.

CER Framework

Adapted from Toulmin (1958)

- **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 Adapted from Toulmin (1958)



Brandon's Revised Explanation

Fat and soap are different substances.
 Fat is of white and soap is milky white.
 Fat is soft squishy and soap is hard.
 Fat is soluble in oil, but soap is not soluble in oil. Soap is soluble in water, but fat is not. Fat has a melting point of 77°C and soap has a melting point above 100°C. Fat has a density of 0.92 g/cm³ and soap has a density of 0.84 g/cm³. These are all properties. Because fat and soap have different properties, I know they are different.

Brandon's Revised Explanation



Are fat and soap are the same substance or different substances?

Fat and soap are different substances. (Claim) Fat is off(f) white and soap is milky white. (#1) Fat is soft squishy and soap is hard. (#2) Fat is soluble in oil, but soap is not soluble. Soap is soluble in water, but fat is not. (#3) Fat has a melting point of 47° C and soap has a melting point above 100° C. (#4) Fat has a density of 0.92 g/cm³ and soap has a density of 0.84 g/cm³. (#5) (Evidence) These are all properties. Because fat and soap have different properties, I know they are different. (Reasoning)

Physics Example



What type of pulley system requires the least force to move the block?

A pulley system with two moveable pulleys and one fixed pulley required the least amount of force to move the block. (Claim) This system took an average of 0.82 Newtons to move the block. We tried three other systems, but the closest one was still 0.23 Newtons more, because it required 1.05 Newtons. (Evidence) The fixed pulleys just change the direction of the force, while moveable pulleys reduce the amount of force. Using one fixed, let us have two moveable pulleys, which decreased the force more than just having one moveable pulley. (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)

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) 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

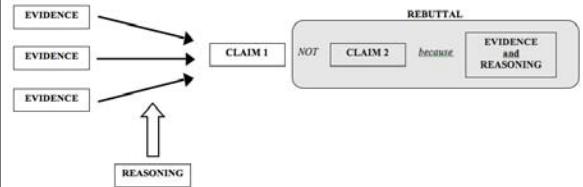
Mr. Garcia: Do you think the climate is changing? Make sure you support your idea with evidence and reasoning.

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).

CER Framework Adapted from Toulmin (1958)



Video Example - Introducing the Framework

Introducing
Claim

Video Example – Everyday - Basketball

Connect to Everyday Examples

Video Example – Everyday - Temptations

Connect to Everyday
Examples

Lunch!



Activity - Analyze Student Writing

With your group, analyze the 7th graders writing:

1. Analyze each student's writing in terms of claim, evidence and reasoning.
2. Rank the students examples from 1 (being the strongest) to 4 (being the weakest).
 - Why did you rank #1 the strongest?
 - What challenges did students have?
3. If you gave this learning task to your students, what challenges do you think they would have? Why?

Activity - Analyze Student Writing: Student A

Conclusion:
(Write a scientific explanation that states whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.)

Claim:
(Write a statement that responds to the original problem about whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.)
Substances were formed because some of the ingredients powdered sugar and road salt

Three pieces of evidence:
(Provide scientific data to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.)
The ingredients showed some signs of chemical reactions and the properties changed. There was also an fizzling of the bag.

Reasoning:
(Write a statement that tells why your data count as evidence to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.)
there is a new substance was formed

Activity - Analyze Student Writing: Student B

Conclusion:
Write a scientific explanation that states whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution.

Claim:
Write a statement that responds to the original problem about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution.

New substances were found after we mixed everything up.

Three pieces of evidence:
Provide scientific data to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.

evidence is the experiment we did, the color and the observation is also evidence.

Reasoning:
Write a statement that tells why your data count as evidence to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.

My data count as evidence because if you look at the evidence and the experiment it all adds up.

Activity - Analyze Student Writing: Student C

Conclusion:
Write a scientific explanation that states whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution.

Claim:
Write a statement that responds to the original problem about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. A new substance was formed after combining the baking soda, powdered sugar, food salt, and phenol red in solution.

Three pieces of evidence:
Provide scientific data to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. Your claim or data should include appropriate scientific principles that defend your claim and evidence. The color of the phenol red solution changes the color of the final product is yellow with some pink. The 4 substances were at room temperature. The new substance got warmer the bag that contained all of the substances inflated (which indicates a gas was formed).

Reasoning:
Write a statement that tells why your data count as evidence to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence. The color of the phenol red solution changes when the new substance is formed. Properties change the same unless the substance changes. The temp increased and a gas was formed. A gas is a new substance, and we know it formed when the substances interacted.

Activity - Analyze Student Writing: Student D

Conclusion:
Write a scientific explanation that states whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution.

Claim:
Write a statement that responds to the original problem about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution.

There was a new substance formed after the 4 substances.

Three pieces of evidence:
Provide scientific data to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.

One piece of evidence was that the color was white then it turned yellow after adding phenol red. Another piece of evidence was that it was powdery then it turned bubbly. One last piece of evidence was that it was about room temp then it was very hot.

Reasoning:
Write a statement that tells why your data count as evidence to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, food salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.

There was a new substance because if it was not a new substance the color, temperature, and texture would not have changed.

Student Challenges

1. Using appropriate and sufficient evidence
2. Providing reasoning
3. Considering alternative explanations or rebuttals

Student Challenges: Using appropriate and sufficient evidence



Students can:

- Just repeat that the experiment or the data table is their evidence
- Rely on their own opinions or personal experiences instead of appropriate data
- Have difficulty using enough or sufficient data
 - May focus on one piece of data
- Struggle with using different types of data
 - May focus on quantitative and not consider qualitative data

Student Challenges: Providing reasoning



Students can:

- Omit describing why they chose or did not use certain data
- Have difficulty describing the link between the claim and evidence
- Struggle with including a general scientific principle

Student Challenges: Considering alternative explanations or rebuttals



Students can

- Focus on one explanation
- Have difficulty seeing that there are potentially multiple different ways to explain a phenomenon
- Struggle with evaluating and articulating why an alternative explanation is not appropriate

Designing Learning Tasks



Step 1: Identify Opportunities in the Curriculum

- 1a. Learning Goal
- 1b. Scientific Data
- 1c. Scientific Principle

Step 2: Design Complexity of the Learning Task

- 2a. Openness of Question
- 2b. Type of Data
- 2c. Amount of Data
- 2d. Inclusion of Rebuttal

Step 3: Create Classroom Supports

- 3a. Visual Representations
- 3b. Curricular Scaffolds

Step 1: Identify Opportunities in the Curriculum 1A - Specify the Learning Goal

- Develop Learning Performance
 - Combines both the science content and the CER framework

Content Standard	× Scientific Inquiry Standard	= Learning Performance
The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull. (NRC, 1996, B: 2/3, K-4)	Use data to construct a reasonable explanation (NRC, A1/D). Communicate investigations and explanations (NRC, A1/E)	Students construct a scientific explanation that includes a claim about how the size of a push impacts the position of an object, evidence in the form of different push and the related distance that an object traveled, and reasoning that the larger the push the greater the distance an object will travel.

Step 1: Identify Opportunities in the Curriculum 1B - Scientific Data

- Engaging in scientific explanation requires identifying places in the curriculum or designing activities when students use and make sense of data.
- Students do not need to collect the data themselves, but there does need to be data they can use as evidence to support their claim.

Step 1: Identify Opportunities in the Curriculum 1C - Scientific Principle

- The tasks needs to align with the scientific principles you want students to learn.
- Students need to be able to apply one or more scientific principles that show why the data counts as evidence to support the claim.

Step 2: Design Complexity of the Learning Task

- 2a. Openness of Question
- 2b. Type of Data (What specific data?)
 - Student collect or provided to students
 - Quantitative versus Qualitative
- 2c. Amount of Data (How much data?)
- 2d. Variation of the Framework

Step 2: Design Complexity of the Learning Task

Characteristic	Simple Task	Complex Task
Openness of Question	Does providing a plant with light 12 hours a day or 24 hours a day impact the growth of a plant?	What factors impact the growth of a plant?
Type of Data	Height in cm of plants	Height in cm of plants Number of leaves, buds and flowers Description of leaves, buds and flowers to indicate health
Amount of Data	3 plants in 2 conditions (6 total plants) Measured once a week for 4 weeks (24 total height measurements)	3 plants each in 8 different conditions to investigate three different variables (24 total plants) Measured once a week for 8 weeks (192 measurements or observations for each type of data)

Variations of the Instructional Framework

Level of Complexity	Framework Sequence
Simple	Variation #1 1. Claim 2. Evidence 3. Reasoning
↓	Variation #2 1. Claim 2. Evidence • Appropriate • Sufficient 3. Reasoning
	Variation #3 1. Claim 2. Evidence • Appropriate • Sufficient 3. Reasoning • Multiple components
	Variation #4 1. Claim 2. Evidence • Appropriate • Sufficient 3. Reasoning • Multiple components 4. Rebuttal
	Complex

Step 3: Create Classroom Supports

Scaffold Type	Example
Visual Representation	Poster on the wall of the classroom titled Scientific Explanation with claim, evidence and reasoning listed underneath and the definition of each component.
Curricular Scaffolds	Sentence starters, prompts or questions included on an investigation sheet to remind and provide students with support around including claim, evidence and reasoning in their written response.



Curricular Scaffolds

Content-Specific Scaffold	Generic Explanation Scaffold
(State whether a chemical reaction occurred in the plastic bag experiment, that is whether it created new substances. Provide a change in properties, such as melting point, solubility, and density, to support whether or not the experiment was a chemical reaction. Tell why properties staying the same or changing tells you whether a chemical reaction occurred.)	<p>Claim (Write a statement that responds to the original problem.)</p> <p>Evidence (Provide scientific data to support your claim. You should only use appropriate data and include enough data.)</p> <p>Reasoning (In your reasoning statement, connect your claim and evidence to show how your data links to your claim using scientific principles.)</p>

Curricular Scaffolds: Combine Content and Generic

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

Evidence: Provide scientific data to support your claim. Use evidence from your table above about the helath and changes for the different charactristics of your ecocolumn.

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.

Fading Support of the General Scaffold

Amount of Support	Generic Explanation Scaffold
Detailed Support	<p>Claim (Write a statement that responds to the original problem.)</p> <p>Evidence (Provide scientific data to support your claim. You should only use appropriate data and include enough data.)</p> <p>Reasoning (In your reasoning statement, connect your claim and evidence to show how your data links to your claim using scientific principles.)</p>
Intermediate Support	<p>Claim (Respond to the problem.)</p> <p>Evidence (Provide scientific data to support your claim.)</p> <p>Reasoning (Connect your claim and evidence.)</p>
Minimal Support	Remember to include claim, evidence, and reasoning.

Activity - Design learning tasks

- Work in Grade Level Groups with your Curriculum

<p>Step 1: Identify Opportunities in the Curriculum (20 min)</p> <p>1a. Learning Goal</p> <p>1b. Scientific Data</p> <p>1c. Scientific Principle</p>
<p>Step 2: Design Complexity of the Learning Task (20 min)</p> <p>2a. Openness of Question</p> <p>2b. Type of Data</p> <p>2c. Amount of Data</p> <p>2d. Inclusion of Rebuttal</p>
<p>Step 3: Create Classroom Supports (20 min)</p> <p>3a. Visual Representations</p> <p>3b. Curricular Scaffolds</p>

Share Learning Task



- On a Large Post-it, record the following:
 - Question you will ask students
 - Example student CER - illustrate the “ideal” response for the different components

Discussion



- How will you introduce the framework and what supports will you provide students for their writing?
- What challenges arose in designing learning tasks?
- What questions do you have about using CER with your students?

Logistics and Wrap-up



- Before March 14 Workshop
 - Read Chapters 1-2
 - Try CER Learning Task with your students. Collect samples of student writing
- March 2 Workshop
 - Same room – Campion Hall, Room 139. at BC
 - Bring 6 samples of student writing (2 stronger, 2 middle, 2 weaker)
 - Bring your science curriculum

Contact information



- Workshop Webpage
 - <http://bpssciencecer.weebly.com>
- Kate McNeill’s contact information
 - Kmcneill@bc.edu
- Mandy Knight’s contact information
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