

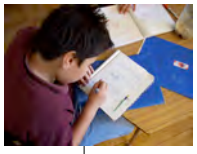

Supporting Students in Science Thinking and Writing

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Mandy Knight
Adam Weatherwax
Boston College

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Agenda

- Introductions
- Feedback and Research
- 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

Break

- Activity - Design learning tasks
- Logistics and Wrap-up

Introductions

- Kate, Mandy, and Adam
- NSF book and teacher workshop grant
- Introduce yourself to the group
  - Name
  - School or Institution
  - Position (e.g. grade level and topics)

Feedback and Research

- Consent Form
  - Pre & Post survey & Videotape Workshop
- Workshop Pre-Survey
  - Similar survey at last workshop
  - We will remove all names and instead put a number so we can compare pre and post.
- Stipend & Certificate
  - February 8 workshop
    - Will receive certificate for 15 professional development hours
    - Complete form for $750 stipend for attending workshops

Activity - Chemistry Investigation

With your table:

- 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 7th grade 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 7th grade 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/cm³*
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 weashing. The 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

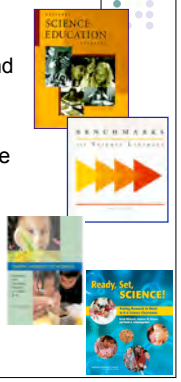
Fat and soap are different substances. Fat is of white and soap is milky white. Fat is soft squishy and soap is hard. Fat is soluble in oil, but soap is not soluble in oil. Soap is soluble in water, but fat is not. Fat has a melting point of 37°C and soap has a melting point above 100°C. Fat has a density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

What are Explanation and Argumentation?

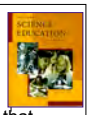
- Explanation
  - *make sense* of how or why a phenomenon occurred
  - Examples:
    - Explain why the biodiversity decreased
    - Explain what has happened to the pitch of bird song in cities
- Argumentation:
  - *Defend or support* knowledge claims through evidence, warrants and backing
  - Examples: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

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.



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.

Benefits of Scientific Explanation

Support students to:

1. Understand science concepts
2. Use evidence to support claims
3. Reason logically
4. Consider and critique alternative explanations
5. Understand the nature of science
6. Engage in academic writing

For teachers:

1. Makes student thinking visible
2. Can serve as an important formative and summative assessment tool

Students' Understandings of Explanation and Argument

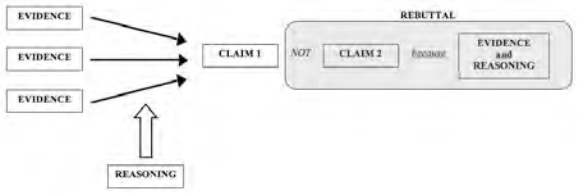
- Students' understandings of explanation and argument does not necessarily match expectations.
- What do you think it means for a scientists to create a scientific explanation?
  - Exchange between people (57%) - *"if they tell somebody, like all the people, like in public that they learned something like new."*
  - Observation (48%) - *"they try to explain what they're doing, sort of like a observing, describing what they see and what they're doing."*
- What do you think it means for a scientists to create a scientific argument?
  - Exchange between people (83%) - *"Well like if he and another scientist are talking about something and then he thinks that the other scientist made a mistake he says, I think this and this."*

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 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 an 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 of(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/cm^3 and soap has a density of 0.84 g/cm^3. (#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) 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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Video Example - Introducing the Framework

Introducing Claim

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 ...

...g soda, packed sugar and road salt

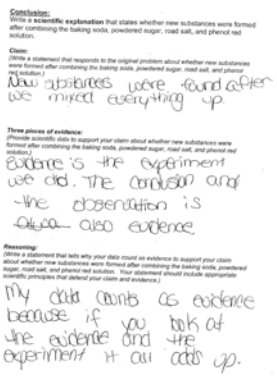
Three pieces of evidence:
(Provide scientific data to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.)

The ingredients showed some signs of ... reactions and the properties changed a. There was also an lightening of the ...

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.)

therefore a new sub stance 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, 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.)

New substances were found after we mixed everything up.

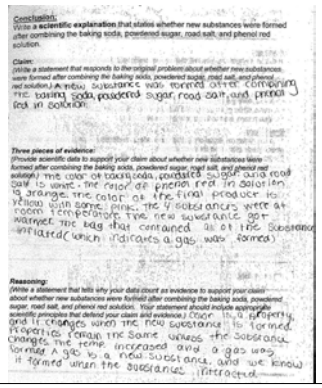
Three pieces of evidence:
(Provide scientific data to support your claim about whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.)

Evidence is the experiment we did. The conclusion 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, road salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.)

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

Activity - Analyze Student Writing: Student C



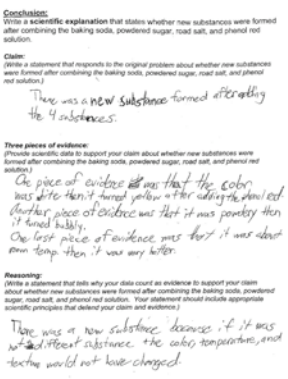
Conclusion:
Write a **scientific explanation** that states whether new substances were formed after combining the baking soda, powdered sugar, road salt, and phenol red solution.

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.) A new substances was formed after combining the baking soda, powdered sugar, road 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, road salt, and phenol red solution.) The color of baking soda, powdered sugar and road salt is white. The color of phenol red in solution is orange. 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 substance 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, road salt, and phenol red solution. Your statement should include appropriate scientific principles that defend your claim and evidence.) Color is a property and it changes when the new substance is formed. Properties remain 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, 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.)

There was a new substance formed after adding 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, road salt, and phenol red solution.)

One piece of evidence was that the color was white then it turned yellow after adding the 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 hotter.

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 was a new substance because if it was not a different 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 X	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, 5-8)	Develop…explanations… using evidence. (NRC, 1996, A: 1/4, 5-8) Think critically and logically to make the relationships between evidence and explanation. (NRC, 1996, A: 1/5, 5-8)	Students construct a scientific explanation that includes a claim about how the size of a force impacts the position of an object, evidence in the form of different forces and the related distance that an object traveled, and reasoning that a force is a push or a pull and that the larger the force 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

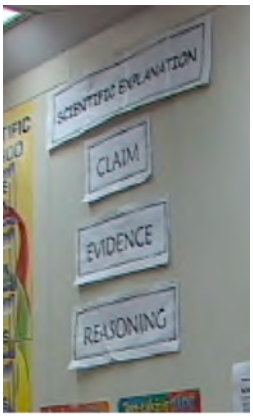
Characteristic	Simple Task	Complex Task
Openness of Question	Does providing a plant with light 12 hours a day or 24 hours a day impact the growth of a plant?	What factors impact the growth of a plant?
Type of Data	Height in cm of plants	Height in cm of plants Number of leaves, buds and flowers Description 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 ↓ Complex	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

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.



Visual Representation

Curricular Scaffolds

Content-specific versus Generic Explanation 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. Do not include measurements that are not properties, such as mass and volume. Tell why properties staying the same or changing tells you whether a chemical reaction occurred.)	**Claim :** (Write a statement that responds to the original problem.) **Evidence**: (Provide scientific data to support your claim. You should only use appropriate data and include enough data. Appropriate data is relevant for the problem and allows you to figure out your claim. Remember that not all data is appropriate. Enough data refers to providing the pieces of data necessary to convince someone of your claim.) **Reasoning:** (In your reasoning statement, connect your claim and evidence to show how your data links to your claim. Also, tell why your data count as evidence to support your claim by using scientific principles. Remember reasoning is the process where you apply your science knowledge to solve a problem.)

- *Combination Explanation Scaffolds*
  - **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.
  - **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.
  - **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 scienctific prinicples that defend your claim and evidence.

Fading Support of the General Scaffold

Amount of Support	Generic Explanation Scaffold
Detailed Support	**Claim** (Write a statement that responds to the original problem.) **Evidence** (Provide scientific data to support your claim. You should only use appropriate data and include enough data. Appropriate data is relevant for the problem and allows you to figure out your claim. Remember that not all data is appropriate. Enough data refers to providing the pieces of data necessary to convince someone of your claim.) **Reasoning** (In your reasoning statement, connect your claim and evidence to show how your data links to your claim. Also, tell why your data count as evidence to support your claim by using scientific principles. Remember reasoning is the process where you apply your science knowledge to solve a problem.)
Intermediate Support	**Claim** (Respond to the problem.) **Evidence** (Provide scientific data to support your claim. You should only use appropriate data and include enough data.) **Reasoning** (Connect yout claim and evidence. Tell why your data counts as evidence using scientific principles.)
Minimal Support	Remember to include claim, evidence, and reasoning.

Break!

Activity - Design learning tasks

- Work in Grade Level Groups with your Curriculum

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

- What are some examples of the learning tasks that groups' designed?
  - What is the learning goal?
  - What question will you ask students?
  - What supports will you provide students?
- What challenges arose in designing learning tasks?
- What questions do you have about using CER with your students?

Logistics and Wrap-up

- Before January 7 Workshop
  - Read Chapters 1-3
  - Try CER Learning Task with your students. Collect samples of student writing
- January 7 Workshop
  - Same room - McElroy Conference Rm. 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
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- Mandy Knight's contact information
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  - weatherw@bc.edu