

**Supporting grades 5-8 students in constructing explanations in science:**  
The claim, evidence and reasoning framework for talk and writing

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## Agenda

- Introductions
- Critique student writing
- Discuss Importance of scientific explanation
- Discuss Video of 7<sup>th</sup> Grade Classroom
- Use rubric to analyze student writing
- Discuss variations of the framework
- Overview of the book and questions

## Context: 7th Grade Chemistry Unit

- **Substances and Properties**
  - Describe observable properties of fat and soap.
  - Determine the density, solubility, and melting point of fat and soap.
  - Key learning goal - Different substances have different properties
- **Chemical Reactions**
  - Investigate three different chemical reactions, boiling, and mixing.
  - Use molecular models to explore whether new substances are produced.
- **Conservation of Mass**
  - Investigate if mass changes in chemical reactions.
  - Use molecular models to explore why mass is conserved during chemical reactions.



## Activity: Critique Students' Explanations

- Examine the two students' explanations
- Questions:
  - How would you assess these responses?
  - What are the strengths of each example?
  - What are the weaknesses of each example?

## 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.



## Central to the New Science Education Frameworks

- Explanations and Arguments are key practices described in the New Science Education Framework
- The released document of the New Science Education Framework cites argumentation and explanation as 2 of 7 key practices:
  - **Explanation and prediction:** Constructing predictions and explanatory accounts of phenomena, including evidence-based explanations (paraphrased)
  - **Argumentation:** Engaging in argumentation to defend or critique scientific questions, designs of investigations, representations and analyses of data, evidence-based explanations, predictions, and scientific models (paraphrased)



## 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:

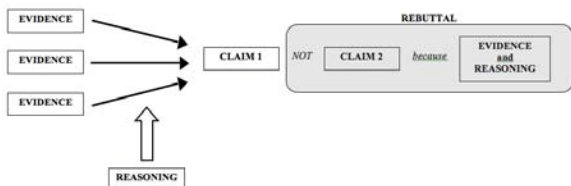
1. Makes student thinking visible
2. Can serve as an important formative and summative assessment tool

## 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)*



## Chemistry Example

*Write a scientific explanation that states whether a chemical reaction occurred when Carlos stirred and heated butanic acid and butanol.*

A chemical reaction did occur. (Claim) Butanic acid and butanol have different solubilities compared to layer A and layer B. Butanic acid and butanol also have different melting points and densities compared to the measurements for layer A and layer B (Evidence). Since the properties are different, layers A and B are new substances, because different substances have different properties. A chemical reaction occurred, because new substances were created from old substances (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?

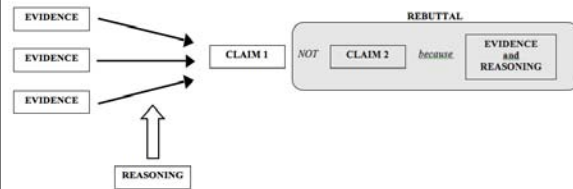
The shark population will die out. (Claim) The shark eats other fish such as the ocean fish and the lantern fish. The ocean fish and the lantern fish eat other organisms such as shrimp and copepods. The shrimp and copepods eat the phytoplankton. (Evidence) Phytoplankton are producers and they make their 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)

## 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)

## CER Framework Adapted from Toulmin (1958)



Video Example - Introducing the Framework



Activity: Assess Students' Writing

- Score the three fifth responses using the specific rubric. For each student give them a separate score for:
  - Claim - 0, 1 or 2
  - Evidence - 0, 1, 2, 3, or 4
  - Reasoning - 0, 1, or 2
- 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 and Specific Rubrics

	Claim	Evidence	Reasoning	Rebuttal
	<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>	<i>Recognizes and describes alternative explanations, and provides counter evidence and reasoning for why the alternative explanation is not appropriate.</i>
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.
V A R I E S	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.
F O M 1 t o 5	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.

Activity: Assess Students' Writing

- Score the three fifth responses using the specific rubric. For each student give them a separate score for:
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## Learning Progression

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

## Variation #1 (potential starting place)

- Claim
  - A statement that answers the question
- Evidence
  - scientific data that supports the claim
- Reasoning
  - a justification for why the evidence supports the claim using scientific principles

## Variation #1

The plant that received more light grew taller. (claim) The plant with 24 hours of light grew 20 cm. The plant with 12 hours of light only grew 8 cm (evidence) Plants require light to grow and develop. This is why the plant that received 24 hours of light grew taller. (reasoning)

## Variation #2 (more complex evidence)

- Claim
  - A statement that answers the question
- Evidence
  - scientific data that supports the claim
  - Data needs to be appropriate
  - Data needs to be sufficient
- Reasoning
  - a justification for why the evidence supports the claim using scientific principles

## Variation #2

The plant that received more light grew more. (claim) On average for the six plants that received 24 hours of light, they grew 20 cm, had six yellow flowers, had fifteen leaves and they were all vibrant green. On average for the six plants that received 12 hours of light, they grew 8 cm, had two yellow flowers, and had four leaves. Also, two of the plants had zero flowers. These plants were still vibrant green, but they were smaller with fewer flowers and leaves. (evidence) Plants require light to grow and develop. This is why the plant that received 24 hours of light grew more (reasoning).

## Variation #3 (more complex reasoning)

- Claim
  - A statement that answers the question
- Evidence
  - scientific data that supports the claim
  - Data needs to be appropriate
  - Data needs to be sufficient
- Reasoning
  - a justification for why the evidence supports the claim using scientific principles
  - each piece of evidence may have a different justification for why it supports the claim

## Variation #3

Plants need water, carbon dioxide and light to grow. (claim) On average for the six plants that received constant light, carbon dioxide and water, they grew 20 cm, had six yellow flowers, had fifteen leaves and they were all vibrant green. On average for the six plants that received 12 hours of light, limited carbon dioxide and limited water, they grew 8 cm, had two yellow flowers, and had four leaves. Also, two of the plants had zero flowers. These plants were still vibrant green, but they were smaller with fewer flowers and leaves. (evidence) Photosynthesis is the process where green plants produce sugar from water, carbon dioxide and light energy. Producing sugar is essential for plant growth and development. That is why the plants that received a constant source of water, carbon dioxide and light grew the most. (reasoning)

## Variation #4 (Add rebuttal)

- Claim
  - A statement that answers the question
- Evidence
  - scientific data that supports the claim
  - Data needs to be appropriate
  - Data needs to be sufficient
- Reasoning
  - a justification for why the evidence supports the claim using scientific principles
  - each piece of evidence may have a different justification for why it supports the claim
- Rebuttal
  - describes alternative explanations and provides counter evidence and reasoning for why the alternative is not appropriate.

## Variation #4

Plants need water, carbon dioxide and light to grow. (claim) On average for the six plants that received constant light, carbon dioxide and water, they grew 20 cm, had six yellow flowers, had fifteen leaves and they were all vibrant green. On average for the six plants that received 12 hours of light, limited carbon dioxide and limited water, they grew 8 cm, had two yellow flowers, and had four leaves. Also, two of the plants had zero flowers. These plants were still vibrant green, but they were smaller with fewer flowers and leaves. (evidence) **Photosynthesis is the process where green plants produce sugar from water, carbon dioxide and light energy. Producing sugar is essential for plant growth and development. That is why the plants that received a constant source of water, carbon dioxide and light grew the most.** (reasoning) Our experimental design just limited the amount of air the plants received not specifically the amount of carbon dioxide. So you could argue that plants need water, air and light. But we know that the process of photosynthesis requires carbon dioxide and not another gas (like oxygen), which is why we concluded specifically that the carbon dioxide was required for growth. If we could limit just the carbon dioxide in our design, we would have better evidence for this claim (rebuttal).

## Learning Progression

Level of Complexity	Framework Sequence
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	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
Complex	4. Rebuttal

## Conclusion

- Scientific explanation/argumentation is a key learning goal for k-12 students.
- Students have difficulty supporting their claims with appropriate evidence and reasoning.
- The framework (claim, evidence, reasoning and rebuttal) can help break down this complex task.
- Rubrics can help identify student strengths and weaknesses and support feedback
- Variations of the framework can be used over time to meet student needs.

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- Chapter 6: Using Rubrics and Student Data to Inform Instruction
- Chapter 7: Supporting Learning Over Time





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