Beyond CER: Explanation and Argument

Distinctions & Implications for Instruction
Check this out . . .

Are these students engaged in the scientific practice of constructing an explanation or engaging in argument?

In groups...

1. Take Day 2 data

2. Write one conclusion statement as a group:
   - Start off by answering your Investigative Question
   - Be sure to include evidence by using relevant data from your experiment
   - And based on this data, explain what you think your yeast are doing in the flask
Why Does it Matter?
Is it important to distinguish between the explanation and argumentation practices in the classroom?
EXPLANATION
DEVELOPING AN ARGUMENT THAT SUPPORTS A CLAIM!

**Claim**  A statement that answers the investigation question

**Evidence**  The analyzed data that supports the claim

**Reasoning**  An argument that shows how the evidence supports the claim
Curiosity + Questions + Investigations = Explanations and Argumentation

- What do you know?
- How do you know that?

Claim + Evidence + Reasoning = Explanation

- Why does your evidence support your claim?
What Is The Issue?

The vision laid out in the NRC Framework for K-12 Science Education asks learners to engage in the science practice of ‘constructing explanations’ and also in ‘argument from evidence’ (along with six other practices). But, some curricula and PD resources don’t make this distinction. They integrate argumentation into explanation and say that it isn’t important for students to understand the difference. Does it matter in the classroom?

WHY IT MATTERS TO YOU

Teachers should help students understand how scientific knowledge is produced through explanation and argumentation.

District staff and PD providers should emphasize the distinction between explanation and argumentation in PD and provide instructional supports and models of each to teachers.

School leaders should learn to recognize what it looks like for student to learn science through argumentation and explanation.
Make a Claim
Ding-Ding!

Which is right?
Students in Video are Practicing ARGUMENT

**Scientific Argument**

**QUESTION**
About the natural world

**CLAIM**
A proposed answer to a question about the natural world

**REASONING**
The process of making clear how your evidence supports your claim

**EVIDENCE**
Information about the natural world used to support a claim

---

**A SCIENTIFIC ARGUMENT**

**THE CLAIM**
State your answer to the guiding question.

- Fits with...
- Supports...

**THE EVIDENCE**
Provide analyzed data (measurements & observations) to support your claim that illustrates trends, comparisons, and/or relationships among variables.

- Supported with...
- Explains...

**JUSTIFICATION OF THE EVIDENCE**
Defend your evidence using relevant scientific concepts.
Students in Video are Practicing EXPLANATION

**SCIENTIFIC EXPLANATIONS**

**CLAIM**
- Statement about the results of an investigation
- A one-sentence answer to the question you investigated.
- It should not start with "you" or "me".
- It should describe the relationship between dependent and independent variables.

**EVIDENCE**
- Scientific data used to support the claim
- Evidence must be:
  - **Sufficient** — Use enough evidence to support the claim.
  - **Appropriate** — Use data that support your claim. Leave out information that doesn’t support the claim.
  - **Qualitative** — Using the senses, or **Quantitative** (numerical), or a combination of both.

**REASONING**
- Ties together the claim and the evidence
- Shows how or why the data count as evidence to support the claim.
- Provides the justification for why this evidence is important to this claim.
- Include one or more **scientific principles** that are important to the claim and evidence.
Ding-Ding!

Which is right?

In this corner, we have the folks who feel the evidence supports that the students are practicing Argument.

In this corner, we have the folks who say they are practicing Explanation.

Go to your Corners!
Finding Evidence

Using the texts provided, work with your claim group to find some evidence to support your claim.
What do you think?

What is your initial claim? Should CER be used for Argument or Explanation?
Digging Deeper
Is it important to distinguish between the explanation and argumentation practices in the classroom?
Things To Consider

- Explanations are constructed from models and representations of reality—not out of data and warrants. With arguments, scientists attempt to logically reason from the data to a conclusion using appropriate warrants. Argumentation often involves comparing different explanations for natural phenomena in an evidence-based way. The two practices are deeply linked to each other, but they do different intellectual work for scientists. Review the Model of Scientific Practices from the NRC Framework to learn more.

- It can be simpler to not distinguish explanation from argumentation—to introduce students to one practice rather than two. This comes with some downsides.

- Argumentation involves a level of uncertainty—one argues to clarify for herself or to persuade others who have a different idea. A measure of uncertainty is powerful for constructing open-ended, authentic investigations for a class. Focusing on explanation and ignoring argumentation may inhibit such investigations. If this intellectual work is only framed for students as explanation then the classroom process of exploring and testing different student ideas through evidence-based argument may not happen. Explanation can easily only focus on finding the “right answer”—rather than developing an understanding of the conceptual ideas.

- Science curricula and assessments will likely differentiate between the two practices since the NRC Framework (and resulting standards) did, so learners need to see them as separate aspects of doing science.
Thus, developing explanatory accounts includes not only construction but also comparison and critique. Attempts to construct new explanations typically require elements of argumentation to support and challenge potential explanations. Indeed, effective classroom supports for scaffolding explanations reflect these elements of argumentation, such as prompting students to support claims with evidence and reasoning (McNeill and Krajcik 2012; Sutherland et al. 2006). We turn next to unpacking this aspect of scientific practice.
Look Again with Fresh Eyes . . .

Let’s dig into Appendix F and read about the practices of Argumentation and Explanation.

APPENDIX F – Science and Engineering Practices in the NGSS

A Science Framework for K-12 Science Education provides the blueprint for developing the Next Generation Science Standards (NGSS). The Framework expresses a vision in science education that requires students to operate at the nexus of three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The Framework identified a small number of disciplinary core ideas that all students should learn with increasing depth and sophistication, from Kindergarten through grade twelve. Key to the vision expressed in the Framework is for students to learn these disciplinary core ideas in the context of science and engineering practices. The importance of combining science and engineering practices and disciplinary core ideas is stated in the Framework as follows:

Standards and performance expectations that are aligned to the framework must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined. At the same time, they cannot learn or show competence in practices except in the context of specific content. (NRC Framework, 2012, p. 218)

The Framework specifies that each performance expectation must combine a relevant practice of science or engineering, with a core disciplinary idea and crosscutting concept, appropriate for students of the designated grade level. That guideline is perhaps the most significant way in which the NGSS differs from prior standards documents. In the future, science assessments will not assess students’ understanding of core ideas separately from their abilities to use the practices of science and engineering. They will be assessed together, showing students not only “know” science concepts, but also, students can use their
### Explanation

<table>
<thead>
<tr>
<th>Grades K-2</th>
<th>Grades 3-5</th>
<th>Grades 6-8</th>
<th>Grades 9-12</th>
</tr>
</thead>
</table>
| Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.  
- Make observations (firsthand or from media) to construct an evidence-based account for natural | Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.  
- Construct an explanation of observed phenomena (e.g., the distribution of plants in | Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.  
- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.  
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer | Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.  
- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.  
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer |

### Argumentation

<table>
<thead>
<tr>
<th>Grades K-2</th>
<th>Grades 3-5</th>
<th>Grades 6-8</th>
<th>Grades 9-12</th>
</tr>
</thead>
</table>
| Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).  
- Identify arguments that are supported by evidence.  
- Distinguish between explanations that account for all gathered evidence and those that do not.  
- Analyze why some evidence is relevant to a scientific question and some is not.  
- Distinguish between | Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).  
- Compare and refine arguments based on an evaluation of the evidence presented.  
- Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.  
- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing | Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).  
- Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.  
- Respectfully provide and receive critiques about one’s explanations, procedures, models, and questions by citing relevant evidence and | Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.  
- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.  
- Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. |
Let’s Hear Your Ideas

What claim does the evidence support?
So, What is the Difference?
<table>
<thead>
<tr>
<th><strong>ARGUMENT</strong></th>
<th><strong>EXPLANATION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Argument attempts to convince someone of something</td>
<td>Explanation attempts to clarify or explain something</td>
</tr>
<tr>
<td>Mainly consists of evidence</td>
<td>Mainly consists of causes or consequences</td>
</tr>
<tr>
<td>Relationship between argument and evidence may be counter argued</td>
<td>Relationship between a fact and an explanation is more solid</td>
</tr>
</tbody>
</table>
Argument: What is the purpose?

"Fred, your cat has fleas. Observe the cat is scratching right now."
RESULTS
At a median follow-up of 16.5 months in a prespecified interim analysis, the 18-month progression-free survival rate was 71.6% (95% confidence interval [CI], 65.5 to 76.8) in the daratumumab group and 50.2% (95% CI, 43.2 to 56.7) in the control group (hazard ratio for disease progression or death, 0.50; 95% CI, 0.38 to 0.65; P<0.001). The overall response rate was 90.9% in the daratumumab group, as compared with 73.9% in the control group (P<0.001), and the rate of complete response or better (including stringent complete response) was 42.6%, versus 24.4% (P<0.001). In the daratumumab group, 22.3% of the patients were negative for minimal residual disease (at a threshold of 1 tumor cell per 105 white cells), as compared with 6.2% of those in the control group (P<0.001). The most common adverse events of grade 3 or 4 were hematologic: neutropenia (in 39.9% of the patients in the daratumumab group and in 38.7% of those in the control group), thrombocytopenia (in 34.4% and 37.6%, respectively), and anemia (in 15.9% and 19.8%, respectively). The rate of grade 3 or 4 infections was 23.1% in the daratumumab group and 14.7% in the control group; the rate of treatment discontinuation due to infections was 0.9% and 1.4%, respectively. Daratumumab-associated infusion-related reactions occurred in 27.7% of the patients.

CONCLUSIONS
Among patients with newly diagnosed multiple myeloma who were ineligible for stem-cell transplantation, daratumumab combined with bortezomib, melphalan, and prednisone resulted in a lower risk of disease progression or death than the same regimen without daratumumab. The daratumumab-containing regimen was associated with more grade 3 or 4 infections. (Funded by Janssen Research and Development; ALCYONE ClinicalTrials.gov number, NCT02195479.)
Consider the Purpose

Argument

- Intended to convince, establish knowledge
- Attempts to show that something is, will be, or should be the case
- Provides a claim, evidence and reasoning to connect the two.

If CER represents an argument, then what is an explanation?
"The reason the cat has fleas is that the weather has been damp."
Something is pulling the universe apart, causing galaxies to flee from each other at an ever-faster rate. Since 1998, when astronomers discovered this bewildering state of affairs, theorists have been struggling to comprehend the mysterious source driving the runaway expansion. Now, researchers have taken one of the first steps toward identifying this bizarre influence, often known as dark energy.

In an analysis of a group of bright but distant exploding stars called type 1a supernovae, researchers have found hints that dark energy is distributed uniformly throughout space and that its strength will remain constant throughout time. That would make dark energy resemble the cosmological constant, a term that Albert Einstein introduced into his general relativity theory in 1917 and quickly abandoned, but which physicists have resurrected several times since. The cosmological constant refers to an unspecified property of space that could add to or oppose gravitational actions…
Explanation

- Purpose is to deepen understanding.
- Seeks to address how and why?
- Involves elaboration on these aspects of a phenomena and often builds from other explanations, and provides a mechanistic or causal account.
How do Argument & Explanation work together?

THE REAL WORLD
- Ask Questions
- Observe
- Experiment
- Measure

COLLECT DATA
TEST SOLUTIONS
- Investigating

ARGUE

CRITIQUE

ANALYZE

THEORIES
AND MODELS
- Imagine
- Reason
- Calculate
- Predict

FORMULATE HYPOTHESES
PROPOSE SOLUTIONS
- Developing Explanations and Solutions

Evaluating
Classroom Tools
Implications

How can we scaffold students with constructing and communicating an explanation?

How can we reinforce the distinction without undermining the authentic ways the practices work together?
Let's build a Scaffold for Explanation

Side by side comparison of basic paragraph structure

<table>
<thead>
<tr>
<th>Argument Paragraph</th>
<th>Explanatory/Informative Paragraph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>Topic Sentence – Main Point</td>
</tr>
<tr>
<td>Evidence</td>
<td>Details to support main point</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Conclusion statement</td>
</tr>
</tbody>
</table>
Let's build a Scaffold for Explanation

<table>
<thead>
<tr>
<th>Argument paragraph</th>
<th>Informative paragraph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim - position</td>
<td>Topic sentence - main point</td>
</tr>
<tr>
<td>Data - evidence</td>
<td>Concrete detail #1 - evidence</td>
</tr>
<tr>
<td>Warrant - explanation &amp; analysis</td>
<td>Commentary - explanation &amp; analysis</td>
</tr>
<tr>
<td>Counterclaim - opposing position</td>
<td>Concrete detail # 2- evidence</td>
</tr>
<tr>
<td>Rebuttal - more evidence and analysis</td>
<td>Commentary - explanation &amp; analysis</td>
</tr>
<tr>
<td>Conclusion statement</td>
<td>Conclusion statement</td>
</tr>
</tbody>
</table>
Beyond CER: A framework to support the practice of constructing/communicating an **explanation**

<table>
<thead>
<tr>
<th>Argument Paragraph</th>
<th>Explanatory Paragraph</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Claim – position</strong></td>
<td><strong>Topic Sentence – Main Point</strong></td>
</tr>
<tr>
<td><strong>Data- evidence</strong></td>
<td><strong>Concrete detail #1 – supporting info/fact</strong></td>
</tr>
<tr>
<td><strong>Warrant – reasoning &amp; analysis</strong></td>
<td><strong>Commentary – elaboration &amp; analysis</strong></td>
</tr>
<tr>
<td><strong>Counterclaim – opposing position</strong></td>
<td><strong>Concrete detail #2 – supporting info/fact</strong></td>
</tr>
<tr>
<td><strong>Rebuttal – more evidence &amp; analysis</strong></td>
<td><strong>Commentary – elaboration &amp; analysis</strong></td>
</tr>
<tr>
<td><strong>Conclusion statement</strong></td>
<td><strong>Conclusion statement</strong></td>
</tr>
</tbody>
</table>
Beyond CER: A framework to support the practice of constructing/communicating an **explanation**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Claim – position about phenomena</strong></td>
<td><strong>Phenomena, Corresponding Question</strong></td>
</tr>
<tr>
<td><strong>Data – Evidence, observations and measurements from investigation</strong></td>
<td><strong>Generate Concrete detail #1 – description, mechanism or cause</strong></td>
</tr>
<tr>
<td><strong>Warrant – Reasoning, connecting the claim and the evidence</strong></td>
<td><strong>Develop Detail #1 – details from investigate, analyze and model, argue</strong></td>
</tr>
<tr>
<td><strong>Counterclaim – opposing position</strong></td>
<td><strong>Generate Concrete detail #2 – description, mechanism or cause</strong></td>
</tr>
<tr>
<td><strong>Rebuttal – more evidence &amp; analysis</strong></td>
<td><strong>Discuss Detail #2 – details from investigate, analyze and model, argue</strong></td>
</tr>
<tr>
<td><strong>Conclusion statement</strong></td>
<td><strong>Answer question about the phenomenon</strong></td>
</tr>
</tbody>
</table>
Applying **Cause & Effect** to the Phenomenon of

2) **CAUSE**
   Describe the cause.

3) **MECHANISM**
   Describe the process that connects the cause & effect.

1) **EFFECT**
   Describe the phenomenon.

1. List any additional or alternative causes.

2. What evidence do you have that this is a cause-effect relationship and not just a correlation?
Applying **Systems & Models** to the Phenomenon of

1) Describe the system.

2) List the components of the system.

3) Illustrate the system in the space provided, and include any relevant interactions among the components of the system.

4) Describe the boundary of the system and any inputs and outputs of matter and energy.

Using the Crosscutting Concepts to Scaffold Student Thinking
By Amy Peacock, Jeremy Peacock | NSTA Blog Published: May 24, 2017

**Figure 1** Arguing for evidence in an explanation

- **Claim:** Fish need their back fin (caudal) to move forward.
  - **Evidence:** We looked at a goldfish in the fish tank. It moved its back fin side to side and swam forward.
  - **Reasoning:** Fish need fins to move. We know this because we saw a goldfish move its back fin side to side and swim forward.

- **Claim:** Fish need their side fins (pectoral) to steer.
  - **Evidence:** We looked at a goldfish in the fish tank. It moved its side fins up and down to change direction.
  - **Reasoning:** Fish need fins to change direction. We know this because we saw a goldfish move its side fins up and down and it changed direction.

- **Claim:** Fish need their top fins (dorsal) for balance.
  - **Evidence:** We took the top fin off of a toy fish, and it lost its balance.
  - **Reasoning:** Fish need fins for balance because a toy fish without its top fin flopped around in the fish tank and couldn’t move straight.

- **Question:** Why do fish have fins?

- **Explanation #1:** Fish use their fins to move forward.

- **Explanation #2:** Fish use their fins to move forward and to change direction.

- **Explanation #3:** Fish use their fins for all kinds of movements and for balance.

The dog has a broken leg.

How do you know?  
Argument

The dog will not put weight on its leg.

How did it happen?  
Explanation

The dog was hit by a car.

Figure 3. Example of linked argument and explanation.
Thank You!

Amy Deller-Antieau
District Science Department Chair, Grades 6-12
Ann Arbor Public Schools
deller@aaps.k12.mi.us

Darcy McMahon
Program Director
Science Mathematics Technology Center
mcmahon@baystem.net
Linked Resources / References

- Because: How to Analyze and Evaluate Ordinary Reasoning by G. Randolph Mayes
- Common Core: Teaching Argument & Informational Paragraph Writing, by Catlin Tucker
- NGSS Appendix F: Science and Engineering Practices
- Engaging Students in the Scientific Practices of Explanation and Argumentation, by B. Reiser, L. Berland and L. Kenyon
- STEM Teaching Tool #1: Is it Important to Distinguish Between the Explanation and Argument and Practices . . . by P. Bell and A. Shouse
- Difference Between Argument and Explanation by Hasa

(cont.)
Linked Resources / References

- Using the Crosscutting Concepts to Scaffold Student Thinking, by A. Peacock and J. Peacock
- The Argumentation Tool Kit
- Learning Progressions Frameworks for English Language Arts & Literacy K-12, Hess, K.